Wheat

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Abstract

Cadmium is the metal that decides most wheat questions. In WHO GEMS/Food, 10,625 common wheat grain results had a median of 28-29 µg/kg, and 4.2% were above the EU maximum of 100 µg/kg for common wheat; lead, total arsenic and total mercury medians sat below their reporting limits. wheat contributes so much dietary cadmium because it is eaten in large amounts, not because its concentrations are unusually high: the joint FAO/WHO expert committee identified wheat as one of the main sources, at 3-29% of the tolerable intake across regional diets.

1 | Wheat overview

Two comparisons matter more than any country ranking. Durum wheat, the hard wheat used for pasta, had a monitoring median of 70 µg/kg cadmium against 20 µg/kg for soft wheat reported by the same European program, and the EU allows it a higher limit (180 against 100 µg/kg).[1,2] Within the kernel, cadmium concentrates in the outer and germ fractions: bran had a median of 64 µg/kg and germ 110 µg/kg, against 28-29 µg/kg in whole grain.[1] Grain from fields beside steel mills, battery plants and mines carried several times more cadmium and lead than grain from background farmland in the same studies.[4,5,9]

For a buyer, the supported priorities are a lot-specific cadmium result compared with the limit for the right wheat type (common, durum, bran or germ), a lead result, and knowledge of where and on what soil the grain was grown.[1,2,10] Imported durum grain from Australia, turkey and Russia measured lower in cadmium than durum from the United States and Canada at Italian border controls, and low-cadmium durum cultivars exist, but these are patterns to verify by testing rather than guarantees.[6,7]

2 | What counts as wheat grain

This page covers wheat grain: common or bread wheat (Triticum aestivum), durum and other tetraploid wheats, the hulled wheats spelt, einkorn and emmer, and the bran and germ milled from them.[1,7,11] wheat flour, bread,

pasta, noodles, breakfast cereals and infant cereals have their own pages and their results are not used here, even when a study measured them alongside grain.[12,13,14]

Material and basis are kept separate because they change the numbers. Durum, spelt, bran, germ and hulled, cracked or rolled grain such as bulgur and flakes are separate rows and separate references, and dry-weight results are never pooled with results on an as-sold or unstated basis.[1,3,14] A WHO region in GEMS/Food is a reporting region, not where the wheat grew, and the European cadmium category "wheat grains and flour" mixes grain with flour, so it is shown separately.[1,12]

3 | How metals reach wheat grain

Metals reach wheat grain mainly through the roots from soil and irrigation water, and their uptake depends on soil cadmium, soil pH, zinc supply and the plant's genetics.[5,6,21] In a mining-area survey, grain cadmium rose with the available soil cadmium and fell as soil pH increased, and in greenhouse pots grain cadmium climbed from about 50 µg/kg on unspiked soil to more than 2,400 µg/kg when soil was spiked with 5 mg/kg cadmium.[5,21]

Point sources and naturally high-cadmium soils both matter. Near a steel mill in Isfahan, grain carried 280-310 µg/kg cadmium and 2,000-2,100 µg/kg lead against 60 and 290 µg/kg at a background site, and grain from a village beside a battery factory in Henan had 320 µg/kg cadmium.[4,9] Karst soils in Guizhou with high natural cadmium gave a mean of 135 µg/kg in 102 farm samples, 45% of them above China's 100 µg/kg limit.[22]

Inside the plant, the HMA3 transporter decides how much cadmium is held in the roots.[6] A non-functional version of its gene, carried by 68% of modern durum cultivars, gives two- to threefold more cadmium transport to shoots and grain, which helps explain why durum accumulates more than common wheat.[6]

4 | Which wheat types and origins measured lower

For cadmium, wheat type is the clearest supported difference. Within European monitoring, soft wheat grain had a median of 20 µg/kg (1,952 results) and durum grain 70 µg/kg (473 results); 21% of durum results were above 100 µg/kg against 1.5% of soft wheat.[1] Spelt, einkorn and emmer grain had a median of 31 µg/kg, close to common wheat, and hulled, cracked or rolled grain such as bulgur and flakes 22-23 µg/kg.[1] This is a supported pattern for cadmium, consistent with the genetics of durum, not a guarantee for any lot.[6]

Among imported durum lots sampled in Italy in 2015-2020, cadmium medians were lowest for grain grown in Australia (8.5 µg/kg, 4 lots) and turkey (17 µg/kg, 10 lots), then Russia (20 µg/kg, 105 lots) and Kazakhstan (25 µg/kg, 151 lots), and highest for Canada (54 µg/kg, 51 lots) and the United States (94 µg/kg, 25 lots).[7] The Russian and Kazakh lots are numerous enough to call tentatively lower than North American durum; the Australian and Turkish figures rest on too few lots for a sourcing preference, and lead pointed the other way, with Turkish durum the highest.[7] Among Ethiopian varieties grown at research centers, the local Wolaita wheat had 47 µg/kg cadmium against 199 µg/kg for the variety Ogolcho, on a dry-weight basis.[14]

Lead, arsenic and mercury offer fewer usable contrasts because most monitoring results are non-detects.[1] Where lead was measured above detection, background farmland differed sharply from contaminated sites, as in Isfahan (290 against 2,000-2,100 µg/kg), and Bijie grain had a lead median of 29 µg/kg.[3,4] Total arsenic in Bijie grain had a median of 54 µg/kg, and households in arsenic-affected districts of Bihar reported raw wheat from below 100 to 500 µg/kg, so groundwater arsenic regions are the main exception to the low arsenic of most wheat.[3,23]

Chromium and nickel varied by region more than by wheat type. In Poland, grain from Lubelskie had a chromium mean of 23 µg/kg against 62 µg/kg in Kujawsko-Pomorskie, and nickel in Ethiopian varieties ranged from 164 to 817 µg/kg.[14,15] The cadmium origin comparisons do not carry over to these metals, and none of the evidence ranks a country as lowest for every metal.[7,15]

Yes, in the monitoring and genetic evidence: European durum grain had a cadmium median of 70 µg/kg against 20 µg/kg for soft wheat, and 21% of durum results exceeded 100 µg/kg.[1] Most modern durum cultivars carry an HMA3 allele that raises cadmium transport to the grain two- to threefold, and the EU sets a higher durum limit of 180 µg/kg to reflect this.[2,6]

At Italian border controls in 2015-2020, durum from Australia (median 8.5 µg/kg, 4 lots), turkey (17), Russia (20) and Kazakhstan (25) was lower than durum from Canada (54) and the United States (94).[7] Turkish durum had the highest lead, so an origin chosen for cadmium should still be tested for lead.[7]

Yes. Durum cultivars with the functional HMA3 allele accumulate less cadmium, Polish wheat (Triticum polonicum) was lower than durum and Khorasan wheat grown in the same Italian field, and Ethiopian varieties ranged from 47 to 199 µg/kg.[6,11,14] In a Nebraska trial of 18 hard winter wheat cultivars, newer cultivars carried slightly more cadmium, about 0.4 µg/kg per year of registration.[24]

5 | Milling fractions and processing

Milling separates the bran and germ, where cadmium is concentrated, from the starchy endosperm that becomes white flour.[1,12] Monitoring medians were 64 µg/kg for bran and 110 µg/kg for germ against 28-29 µg/kg for whole grain, and inorganic arsenic was also higher in bran (median 14-17 µg/kg) than in grain.[1] The European cadmium opinion likewise reported bran and germ at a mean of 64.7 µg/kg against 30.0 µg/kg for wheat grains and flour.[12]

A review citing durum milling studies reports that milling reduced nickel most, then arsenic, cadmium and lead, but gives no measured percentages.[25] Flour and finished foods are assessed on their own pages, so this page does not state how much cadmium a given flour retains.

No study in the library measured cleaning, sorting or washing of wheat grain against a control for metals. Roasting and crushing grain for soy sauce did not remove cadmium: the roasted, crushed wheat used in one Japanese brewing study still carried 57 µg/kg.[26]

It moves cadmium out of the main stream: bran (median 64 µg/kg) and germ (110 µg/kg) carry more than whole grain (28-29 µg/kg), so flour milled from the endosperm carries less than the grain it came from.[1] The removed bran and germ keep the cadmium, which is why the EU sets higher limits for them (150 and 200 µg/kg).[2]

6 | Mitigation from field to mill

Controls for wheat act mainly in the field: choosing soils and sites, wheat type and cultivar, zinc nutrition and crop protection.[4,6,21,24] Measured effects come from a field trial with fungicide, a greenhouse zinc trial on spiked soil and genetic studies of durum; site and pH comparisons are observational.[5,6,21,24] After harvest, separating bran and germ lowers cadmium in the remaining fraction, and lot testing against the right limit detects high lots without removing anything.[1,8]

7 | Trade-offs and limits of controls

Low-cadmium choices can move the problem rather than solve it.[6,7] A low-cadmium durum line grew less under zinc deficiency, and Turkish durum, among the lowest in cadmium at Italian border controls, had the highest lead.[6,7] Whole-grain and bran products keep fibre and minerals that refined flour loses, but they also keep more cadmium.[1,12]

Some field measures help one metal and not another. Selenium given to wheat as selenite or selenate raised mercury in grain in a hydroponic experiment, and only a 1:1 mixture lowered it.[27] Zinc fertilisation lowered grain cadmium in a spiked-soil trial, but could not bring grain from soil with 1 mg/kg added cadmium below 200 µg/kg.[21]

8 | Testing wheat for metals

A useful wheat test must quantify well below the applicable cadmium limit, which in the EU is 100 µg/kg for common wheat, 180 µg/kg for durum, 150 µg/kg for bran and 200 µg/kg for germ.[2] Monitoring laboratories reported cadmium limits of a few µg/kg, and a border-control study of durum used ICP-MS with quantification limits of 4 µg/kg cadmium and 12 µg/kg lead.[1,7] Several surveys reported values that cannot be reconciled with their own methods, including means below their own quantification limits and results above the calibration range, so method, limits and reference-material checks should accompany every result.[13,16,19,28]

Report non-detects with their limit, keep the method and laboratory, and separate total from inorganic arsenic.[1] Most European inorganic arsenic values for wheat were estimated as 70% of total arsenic rather than measured, so a measured inorganic arsenic result is more informative than a converted one.[20] Arsenic measured after dry ashing at 550 °C, as in one Iranian survey, can be lost and is not used.[29]

Some come from contaminated sites, such as grain beside a steel mill in Isfahan (2,000-2,100 µg/kg lead).[4] Others do not survive a check against their own papers: a Bangladeshi survey labeled oven-dried samples as fresh weight, and an Indian effluent study gave no consistent unit.[17,18]

9 | Buying and verifying wheat

Ask for lot-specific cadmium and lead results with the laboratory's quantification limit, compared with the limit f or the exact material: EU 100 µg/kg cadmium for common wheat, 180 for durum, 150 for bran and 200 for g erm, and 200 µg/kg lead for cereals.[2] Limits differ by market: Codex sets 0.2 mg/kg cadmium for wheat, China 0.1 mg/kg cadmium, 0.2 lead, 0.02 mercury, 0.5 total arsenic and 1.0 chromium, Australia and New Zealand 0.1 mg/kg cadmium, and MERCOSUR 0.20 mg/kg for cadmium, lead and arsenic in wheat and its derivatives.[10,30,31,32] From July 2026 the EU also limits nickel to 0.80 mg/kg in common wheat and 1.5 mg/kg in durum.[33]

Specify the wheat type and record the growing country and region separately from the market where the grain was bought.[1,7] For durum, origin and cultivar both shifted cadmium in the evidence: border-control lots from Russia and Kazakhstan were lower than those from Canada and the United States, and cultivars carrying the functional HMA3 allele accumulate less.[6,7] Ask whether fields are near mines, smelters, battery or steel plants or irrigated with wastewater, and for soil cadmium and pH where the grower knows them.[4,5,9]

10 | Exposure from wheat

Wheat matters for exposure because of how much is eaten.[8,34] In China, a wheat and wheat flour monitoring group averaged 21 µg/kg cadmium in 20,925 samples and was eaten at about 145 g a day.[34] The joint FAO/WHO committee estimated that a cadmium limit of 100 µg/kg for wheat, rather than 200, would lower mean wheat cadmium by 22% but cut the highest intake by only about 6% of the tolerable intake.[8]

Bread, pasta and other products made from wheat are measured on their own pages, and this page does not transfer grain concentrations to them. In the European cadmium opinion, bread and pasta averaged 13.7 µg/kg against 30.0 µg/kg for wheat grains and flour, which reflects dilution with water and milling rather than removal.[12]

11 | Evidence review and remaining gaps

This assessment covers every source record in the HMI library that is tagged to wheat or names it, plus every wheat row in WHO GEMS/Food, the FDA Total Diet Study and other indexed datasets; each has a recorded decision based on its content. The FDA Total Diet Study has no wheat grain food, only bread, cereals, pasta, flour and cream of wheat, so it contributes no rows here. Thirteen sources are held in part because their values could not be reconciled with their own methods or figures.[35,13,14,15,16,17,18,19,23,28,29,36]

The main gaps are origin, inorganic arsenic and controlled interventions. Monitoring data identify reporting regions rather than growing countries, inorganic arsenic was measured in a few hundred grain results, and most mitigation evidence comes from pots, a single field trial or genetics rather than commercial fields.[1,6,21,24]

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 | Wheat FAQs

Cadmium is found in almost every wheat sample, typically 20-70 µg/kg depending on the wheat type, while lead, arsenic and mercury are usually below detection.[1] wheat also carries nickel and chromium in the hundreds of µg/kg, and aluminum in the thousands.[3,37]

Through the roots, from soil and irrigation water; uptake rises with soil cadmium and falls as soil pH rises.[5] Fields near steel mills, battery plants and mines give grain with several times more cadmium and lead than background farmland.[4,9]

The library holds no reliable comparison of organic and conventional wheat grain. The one survey of ecological bran reported cadmium values that failed checks against the paper itself, so it cannot answer the question.[35]

Common (soft) wheat and spelt measured lower than durum: European medians were 20 µg/kg for soft wheat, 31 for spelt, einkorn and emmer, and 70 for durum.[1] Within durum, cultivars with the functional HMA3 allele accumulate less.[6]

For durum sampled at Italian border controls, Australia, turkey, Russia and Kazakhstan were lower than Canada and the United States (medians 8.5-25 against 54-94 µg/kg).[7] For common wheat, monitoring data identify only reporting regions, not growing countries, so no country ranking is supported.[1]

Yes, but at concentrations set by milling and recipe: in the European cadmium opinion, bread and pasta averaged 13.7 µg/kg against 30.0 for wheat grains and flour.[12] Each product is assessed on its own page from its own measurements.

Wheat is a major dietary source of cadmium because it is a staple: the joint FAO/WHO committee estimated it at 3-29% of the tolerable intake across regional diets.[8] Cadmium accumulates in the kidney over years, so the concern is long-term intake from staple foods rather than any single meal; occurrence data alone do not establish individual risk.[8]

Yes. The EU sets cadmium at 100 µg/kg for common wheat, 180 for durum, 150 for bran and 200 for germ, and lead at 200 µg/kg for cereals; Codex sets 0.2 mg/kg cadmium for wheat.[2,10] China sets 0.1 mg/kg cadmium, 0.2 lead, 0.02 mercury, 0.5 total arsenic and 1.0 chromium for grain, and from July 2026 the EU limits nickel to 0.80 mg/kg in common wheat and 1.5 mg/kg in durum.[30,33]

Milling separates the cadmium-rich bran and germ from the endosperm used for white flour, but it moves cadmium rather than destroying it.[1] No study in the library measured cleaning or washing grain against a control.

Wheat contains little arsenic of any form outside groundwater-arsenic regions: inorganic arsenic in monitored grain had a median of 2-9 µg/kg.[1] Most European figures were estimated as 70% of total arsenic rather than measured, so a measured inorganic arsenic result is the better evidence.[20]

Whole grain contains the bran and germ, which carry more cadmium (medians 64 and 110 µg/kg) than whole grain overall (28-29 µg/kg).[1] Products made from whole grain therefore keep more of the grain's cadmium than r efined flour does; flour itself is measured on the wheat flour page.[12]

For cadmium, spelt, einkorn and emmer grain had a monitoring median of 31 µg/kg, about the same as common wheat, and lower than durum.[1] A German laboratory found less aluminum in spelt (median 370 µg/kg) than in wheat (3,000 µg/kg), though the table does not say whether the samples were grain or milled.[37]

In GEMS/Food, 4.2% of common wheat grain results exceeded 100 µg/kg, 1.1% of durum results exceeded 180, 1.7% of bran results exceeded 150 and 4.2% of germ results exceeded 200.[1,2] Exceedance was common in high-cadmium regions: 45% of wheat from Guizhou karst soils exceeded China's 100 µg/kg limit.[22]

In a greenhouse trial with durum on cadmium-spiked soil, adequate soil zinc plus a foliar zinc spray gave the lowest grain cadmium at every cadmium dose.[21] At the 0.2 mg/kg dose grain fell from 239 to 182 µg/kg, but zinc could not bring grain from more heavily spiked soil below 200 µg/kg.[21]

In a Nebraska field trial of 18 hard winter wheat cultivars released between 1933 and 2013, newer cultivars carried slightly more cadmium, about 0.4 µg/kg per year of registration, without fungicide.[24] For durum, the high-cadmium HMA3 allele is more common in modern cultivars (68%) than in landraces (26%).[6]

In the same Nebraska trial, a single fungicide application at booting lowered the range of cultivar cadmium means from 100-190 to 70-140 µg/kg.[24] The authors attribute this to larger yields diluting cadmium and caution that other fungicide chemistries were not tested.[24]

Yes, in every such study here: grain near a steel mill in Isfahan had 280-310 µg/kg cadmium and 2,000-2,100 µg/kg lead against 60 and 290 at a background site.[4] Grain beside a battery factory in Henan had 320 µg/kg cadmium, and 24 of 25 fields in a Chinese copper mining area exceeded 100 µg/kg.[5,9]

Wheat grain carries hundreds of µg/kg of nickel: 330 µg/kg on average in an early Nordic compilation and a median of 468 µg/kg in Bijie, Guizhou.[3,38] From July 2026 the EU sets nickel limits of 0.80 mg/kg for common wheat and 1.5 mg/kg for durum, and the Bijie maximum (5,034 µg/kg) shows that some grain exceeds them.[3,33]

Germ was higher in cadmium than bran in monitoring data (median 110 against 64 µg/kg), and both were higher than whole grain.[1] For inorganic arsenic, bran (median 14-17 µg/kg) was higher than grain; too few germ results exist to compare.[1]

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PEER-REVIEWED

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PEER-REVIEWED

STATUS AND LICENCE

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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/wheat#sources.

PUBLICATION HISTORY

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