Tomato

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Abstract

Fresh tomato usually carries little lead or cadmium. In 2,778 WHO GEMS/Food lead results for fresh tomato from 1998 to 2020, about two in three were below the laboratory's detection limit, the median l ay between 0 and 7.5 µg/kg, and 86 (3.1%) were above 50 µg/kg, the EU maximum for fruiting v egetables. Cadmium was detected in half of 3,197 results, with a median between 0 and 5 µg/kg, a nd 137 (4.3%) were above the EU maximum of 20 µg/kg.

1 | Tomato overview

United States market baskets were lower still. In 27 FDA Total Diet Study samples of raw tomato bought from 2017 to 2020, cadmium was found in 24 at 1.0-7.6 µg/kg (median 3.3 µg/kg), while lead, total arsenic, mercury, nickel, chromium and uranium were below reporting limits of 1-50 µg/kg in every sample.[3] Retail and market surveys on a fresh-weight basis in Poland, Iran, Egypt and Romania found mean lead of 7-241 µg/kg and mean cadmium of 3-27 µg/kg.[9,10,11,12,13,14]

The high values in the literature come from exposed growing sites, from studies reporting on a dry-weight basis, and from papers whose figures do not survive a check. Tomatoes grown near two Chinese coal-fired power plants held 9.8-76 µg/kg mercury against 0.73 µg/kg in a grocery-store sample, and Cairo tomatoes irrigated with industrial wastewater held about two and a half times the nickel and chromium of Nile-irrigated fruit.[4,5] A tomato is about 94% water, so a dry-weight result is roughly 17 times the fresh-weight concentration of the same fruit; this page keeps the two bases apart, and holds values from 17 papers that conflict with their own methods or tables.[11,15,16,17]

For a buyer, the supported priorities are the growing site and the irrigation water, and lot results on a fresh-weight basis with quantification limits well below the EU maxima of 50 µg/kg lead and 20 µg/kg cadmium.[2,4,5,6] Codex sets 50 µg/kg lead for fruiting vegetables in its 2025 edition, but its cadmium maximum for fruiting vegetables does not apply to tomatoes.[18]

2 | What counts as fresh tomato

This page covers fresh tomato fruit (Solanum lycopersicum) of any type, including cherry, plum and grape tomatoes raw or of unstated preparation.[1,19,9] Canned tomatoes, paste, purée, sauce, ketchup juice, dried soup tomato and dishes that contain tomato have their own pages, and their values are not used here; tree tomato (tamarillo) is a different plant.[1,3]

Weight basis matters more for tomato than for most foods. Fresh tomatoes were 94.0-94.3% water in the surveys that measured it, so a concentration per kilogram of dry matter is about 17 times the concentration per kilogram of fresh fruit.[11,17] Many surveys dry the samples before analysis and do not state which basis they report; those results are shown, but compared only within their own study, because they cannot be placed on either basis.[20,21,22]

Place names need the same care. A GEMS/Food region is the region that reported the result, and its domestic and imported labels are relative to a reporting country the export does not name, while most surveys report the market where the tomatoes were bought.[1,12,23] Greenhouse, field and organic labels in the monitoring data are the submitters' food names and were not verified.[1]

3 | How metals reach tomatoes

Most of what reaches tomato fruit reflects the growing site: soil, irrigation water and air. In a four-year Chinese field trial, fruit irrigated with half reclaimed water held more cadmium (29 against 18 µg/kg) and chromium (61 against 49 µg/kg) than fruit irrigated with groundwater, although only the chromium difference approached statistical significance.[6] In Cairo, fruit from farms irrigated with untreated industrial wastewater held 760 µg/kg chromium and 1,630 µg/kg nickel against 290 and 610 µg/kg on farms irrigated from the Nile; the same paper's l ead and cadmium values cannot be reconciled with its own soil data and are held.[5]

Air is the main route for mercury near large emitters. Around a Chinese coal-fired power plant, tomato mercury fell from 76.3 µg/kg at the nearest site to 9.8 µg/kg at the farthest, and two sites near a second plant held 71.8 and 29.8 µg/kg, against 0.73 µg/kg in tomatoes from a grocery store.[4]

Experiments show the same dependence on water and soil. Fruit arsenic rose to 0.18 and 0.43 µg/g dry weight when irrigation water was spiked to 500 and 1,000 µg/L arsenic in Burkina Faso, about 0.02 and 0.05 µg/g on a fresh-weight basis.[26] In Egypt, fruit grown with agricultural drainage water held 1,000 µg/kg nickel in a greenhouse plot and 88 µg/kg in a field plot, and remediating the soil with clay minerals and treating the water lowered these to 250 and 18 µg/kg; cadmium was not detected in any treatment.[27] In a Dominican greenhouse trial, lead, cadmium and arsenic stayed below 10 µg/kg in fruit whether the plants received mineral fertilizer, a seaweed-based biofertiliser or nothing.[28]

4 | Which tomatoes and growing conditions measured lower

For lead, the lowest results came from the United States and from Americas monitoring submissions. All 27 FDA market-basket samples were below 4 µg/kg, and in GEMS/Food the detected lead results had a median of 2.1 µg/kg in the Americas, 4.3 µg/kg in the Western Pacific and 18 µg/kg in Europe, with 2.2%, 2.6% and 3.7% of results above 50 µg/kg.[1,3] Part of that difference is analytical: European lead results had a median detection limit of 8 µg/kg, often 10-50 µg/kg, against 1 µg/kg in the Americas, so this is a tentative pattern among reporting regions, not a sourcing preference for a country.[1]

Growing-system labels did not separate lead in the monitoring data, but one controlled comparison did. In Americas submissions from 2014 to 2016, greenhouse-labeled tomatoes had a detected lead median of 2.2 µg/kg (54 of 156 detected), organic-labeled 1.7 µg/kg (19 of 46) and unlabelled 2.0 µg/kg; only three of ten field-labeled results were detected, too few to compare.[1] In Shanghai, hydroponically grown tomatoes held 5.6 µg/kg lead and cadmium combined against 47.9 µg/kg for soil-grown tomatoes from 20 and 22 farm samples, a significant difference; the paper does not give the two metals separately for tomato or state the weight basis.[8]

Type also mattered in one Romanian survey. After washing in tap water, red cherry tomatoes from the market held 18.6 µg/kg lead and no detectable cadmium against 66.8 µg/kg lead and 16.5 µg/kg cadmium in standard tomatoes, while yellow cherry tomatoes held 51.3 µg/kg lead and 23.5 µg/kg cadmium.[9] Total arsenic did not follow: it was 334 µg/kg in red cherry and 389 µg/kg in standard tomatoes, so the type lowest in lead was not lowest in arsenic.[9]

For cadmium, fresh-weight means were lowest in Poland and western Iran and highest in Egypt and northern Iran. Ten Polish tomatoes averaged 3 µg/kg and 50 composites from Hamadan 3 µg/kg, against 9-15 µg/kg in Tehran, 25.5 µg/kg in Ismailia and 27 µg/kg in Babol; the GEMS/Food detected medians were 5 µg/kg in Europe and 9-12 µg/kg in the Americas, Western Pacific and Eastern Mediterranean.[1,10,11,12,13,14] These are single surveys with different methods, so they describe the lowest observed means rather than reliably cleaner regions.

For arsenic and nickel, within-study comparisons point to water and site rather than to a country. Total arsenic was below 3 µg/kg in every FDA sample and inorganic arsenic below 3 µg/kg in four Hong Kong total-diet composites, and EFSA put mean inorganic arsenic in 484 European tomato results at 1.5-7.7 µg/kg, mostly estimated from total arsenic; tap-washed Romanian tomatoes, by contrast, held 255-389 µg/kg total arsenic.[3,9,29,30] Nickel was below 40 µg/kg in every FDA sample and 161-232 µg/kg in Tehran, against an EU maximum of 400 µg/kg; in Seville urban gardens it ranged from 160 µg/kg dry weight in a peri-urban garden to 460 µg/kg in market tomatoes, the reverse of cadmium, which was highest in that peri-urban garden (228 against 73 µg/kg).[3,31,24,13]

Not clearly in the monitoring data: Americas submissions labeled greenhouse or organic had detected lead medians of 2.2 and 1.7 µg/kg against 2.0 µg/kg for unlabelled tomatoes.[1] The one controlled comparison of growing systems found hydroponic tomatoes far lower in lead and cadmium combined than soil-grown tomatoes, 5.6 against 47.9 µg/kg.[8]

On a fresh-weight basis, the lowest means were 3 µg/kg in Poland and in Hamadan, Iran, and the FDA median was 3.3 µg/kg; Tehran, Ismailia and Babol were higher at 9-27 µg/kg.[3,10,11,12,13,14] Each figure comes from one survey, so these are lowest observed values, not a ranking of countries.

5 | Washing, cooking and processed products

Washing removes part of the metal measured on tomatoes, and an acidic soak removed more. In Romania, soaking tap-washed market tomatoes in 5% vinegar lowered total arsenic from 389 to 202 µg/kg, cadmium from 16.5 to 12.2 µg/kg and lead from 66.8 to 54.0 µg/kg on a fresh-weight basis; a 10% soak gave similar results.[9] The paper's text reports larger reductions than its own tables, and there was no unwashed comparison, so the m easured effect is the tables' smaller one.[9]

Cooking cannot destroy a metal, and cookware can add one. Boiling Burkina Faso tomatoes in arsenic-free water did not lower arsenic per gram of dry matter in fruit from spiked irrigation: it was 0.43 µg/g before and 0.71 µg/g after.[26] Baking fresh tomato in aluminum foil raised aluminum from 80 to as much as 370 µg/kg fresh weight, and simmering commercial tomato sauce with stainless steel for six hours raised nickel from about 0.15 to about 5-6 mg/kg, an effect that fell to about 0.7 mg/kg once the steel had been used for six cooking cycles.[7,32]

Canned and concentrated products are separate foods. Studies of canned tomato products measured tin migrating from the can during storage, which fresh tomato does not carry; those results are on the canned tomato and tomato paste pages.[33,34]

6 | Mitigation from field to kitchen

Controls for tomato act mostly before harvest. The measured comparisons concern irrigation water, distance from industrial emitters, soil remediation and growing system, with acidic washing, cookware choice and lot testing after harvest.[4,5,6,7,8,9,32,27] Most are single studies or observational comparisons, so the table records their direction and size without implying they would transfer unchanged to another farm.

7 | Trade-offs and limits of controls

No single lever lowered every metal. In Seville urban gardens, the peri-urban plot had the lowest chromium and nickel but the highest cadmium and, narrowly, lead, and among Romanian tomatoes the cherry type lowest in

lead was not lowest in arsenic.[9,24] In the Egyptian trial, the greenhouse plot carried about ten times the fruit nickel of the field plot on a different soil, so “greenhouse” alone is not a lower-metal label.[27]

Some post-harvest controls have their own costs. A vinegar soak also changes the fruit, and the Romanian study did not measure quality; stainless steel’s nickel and chromium release fell with repeated use, so a new pan m atters more than an old one; and more acidic or spiced tomato dishes leached more aluminum from foil.[7,9,35] Hydroponic growing lowered lead and cadmium in one study, but its nutrient water itself carried lead (0.036 mg/L), and the authors recommend pollution-free water.[8]

8 | Testing tomatoes for metals

A useful tomato test reports lead and cadmium on a fresh-weight basis, with quantification limits well below the 50 µg/kg and 20 µg/kg EU maxima.[2] FDA reported lead and cadmium down to 4 and 1 µg/kg; in GEMS/Food the median European lead detection limit was 8 µg/kg, and eight non-detect records with limits of 1,000-3,000 µg/kg could not place a result at all.[1,3]

Most of the academic literature is less informative than its numbers suggest. Many papers report neither detection limits nor weight basis, several compare dry-weight results with fresh-weight limits, and 17 had values that conflict with their own methods, units or tables, including lead of 26 mg/kg in four different vegetables and a table with no unit at all.[5,15,16,17,23,36]

Record the growing site, irrigation source, growing system and type with every result, and report non-detects with their limit.[4,6,8,9] Chromium results are total chromium; no source in the ledger measured hexavalent chromium or methylmercury in tomato.[4,37]

Some reflect dry-weight reporting, which multiplies a fresh concentration by about 17, and some reflect exposed sites such as coal-plant surroundings.[4,11] Others do not survive a check against their own papers, such as Cairo fruit lead of 22-361 mg/kg on farms whose soil held 0.5-92 mg/kg, or an Indian table with no unit that the abstract gives in mg/g.[5,15]

9 | Buying and verifying tomatoes

Ask for lot-specific lead and cadmium results on a fresh-weight basis with the laboratory’s quantification limit, c ompared with the limit in the destination market.[2,18] The EU applies 50 µg/kg lead, 20 µg/kg cadmium and, from July 2025, 400 µg/kg nickel to fruiting vegetables on a fresh-weight basis after washing, and EFSA’s food c lassification places tomatoes among fruiting vegetables.[2,29,31] Codex sets 50 µg/kg lead for fruiting vegetables and no cadmium maximum for tomatoes.[18]

Ask where and how the tomatoes were grown, not only where they were packed. The supported reasons are distance from coal-fired power plants for mercury, irrigation with wastewater or reclaimed water for chromium, nickel and cadmium, and arsenic in irrigation water.[4,5,6,26] Hydroponic production measured lower lead and cadmium in one study; greenhouse, field and organic labels did not separate lead in monitoring data.[1,8]

10 | Exposure from tomato

Tomato is eaten in large amounts, so even low concentrations matter for intake. Adults ate 109 g of tomato a day in an Iranian survey and 75.6 g of fresh tomato a day in Lebanon, the second-highest intake of any food in

that survey.[11,38] In Hamadan, tomato gave an estimated 0.011 µg/kg body weight a day of lead and 0.005 µg/kg of cadmium, and in Ismailia it supplied 16% of estimated cadmium intake and 9% of lead intake.[11,12]

National diet studies put tomato among the minor sources. Australia's 25th Total Diet Study found that tomatoes, e ggplant and okra together supplied 2-3% of cadmium exposure, and no source in the ledger estimated tomato's sh are of arsenic or mercury intake.[39]

11 | Evidence review and remaining gaps

Every record and dataset row that names tomato, or that discovery matched through the alias list, was decided on its content: 38 studies and reports and two datasets contribute fresh-tomato results.[1,3] Values from 17 papers are held because they conflict with their own methods, units or tables, among them Cairo lead and cadmium, Indian effluent-irrigated values with no unit, Polish fresh-mass values above their own dry-mass results, and Ethiopian lead identical across four vegetables.[5,19,15,16] Gaps remain: no source measured hexavalent chromium or methylmercury in tomato, Australia's raw-tomato results sit in an appendix not in the library, and some surveys p rint their tomato values only in figures.[39,37,40]

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 | Tomato FAQs

Cadmium is the metal most often detected in fresh tomato, usually at a few µg/kg: half of 3,197 GEMS/Food results and 24 of 27 FDA samples had measurable cadmium.[1,3] Lead is detected less often, and arsenic, mercury, nickel and chromium were below reporting limits in every FDA sample, though exposed growing sites can raise any of them.[1,3,4,5]

Mainly from the soil and irrigation water at the growing site, and from air near large emitters.[4,5,6] Fruit near a coal-fired power plant held up to 76.3 µg/kg mercury against 0.73 µg/kg in a grocery-store sample.[4]

No. Organic-labeled tomatoes in Americas monitoring data had a detected lead median of 1.7 µg/kg and cadmium of 8.2 µg/kg, close to unlabelled tomatoes.[1] Organically grown Polish tomatoes measured on a dry-weight basis held 26-139 µg/kg lead and 71-216 µg/kg cadmium.[19]

In one Romanian survey, red cherry tomatoes held 18.6 µg/kg lead and no detectable cadmium against 66.8 µg/kg lead and 16.5 µg/kg cadmium in standard tomatoes.[9] Their arsenic was similar, and no other study compared types under one method, so this is a single observation.[9]

United States market baskets were lowest for lead (all below 4 µg/kg) and among the lowest for cadmium (median 3.3 µg/kg), and Polish and western Iranian surveys found fresh-weight cadmium means of 3 µg/kg.[3,10,11] These are purchase markets or single surveys; the evidence supports avoiding exposed sites more than choosing a country.[4,5]

They are different foods: concentration removes water, and canned products can take up tin from the can during storage.[33,34] Their results are on the canned tomato, tomato paste and tomato sauce pages rather than on this page.

Tomato is eaten in large amounts, so it contributes to intake even at low concentrations; it supplied 16% of estimated cadmium intake in Ismailia, Egypt, but 2-3% together with eggplant and okra in Australia.[12,39] Measured concentrations are not a safety verdict for any individual diet.

Yes. The EU limits fruiting vegetables, the food group in which EFSA classifies tomatoes, to 50 µg/kg lead and 20 µg/kg cadmium on a fresh-weight basis after washing, and to 400 µg/kg nickel from July 2025.[2,29,31] Codex sets 50 µg/kg lead for fruiting vegetables in its 2025 edition, and its cadmium maximum for fruiting vegetables does not apply to tomatoes.[18]

Partly. In a Romanian study, soaking tap-washed tomatoes in 5% vinegar lowered total arsenic by about half, cadmium by 26-61% and lead by 19-24%.[9] Metal taken up into the fruit is not removed by washing.

No. Boiling did not lower arsenic per gram of dry matter in tomatoes from arsenic-spiked irrigation.[26] Cookware can add metals: foil baking raised aluminum from 80 to 370 µg/kg, and new stainless steel raised nickel and chromium in simmered tomato sauce.[7,32]

Few results separate the forms: 11 of 38 European GEMS/Food inorganic arsenic results were detected, at up to 38.8 µg/kg, four Hong Kong composites were below 3 µg/kg, and EFSA estimated a mean of 1.5-7.7 µg/kg across 484 European results.[1,29,30] Most studies measured total arsenic only.[1,9]

In the studies that compared it, yes for chromium, nickel and cadmium: Nile-irrigated Cairo fruit held 290 µg/kg chromium and 610 µg/kg nickel against 760 and 1,630 µg/kg with industrial wastewater.[5] Half reclaimed water in a Chinese trial raised cadmium from 18 to 29 µg/kg and chromium from 49 to 61 µg/kg, smaller differences that were not clearly significant.[6]

In one Shanghai study, yes: hydroponic tomatoes held 5.6 µg/kg lead and cadmium combined against 47.9 µg/kg for soil-grown tomatoes.[8] Its nutrient water still carried lead (0.036 mg/L), so the result depends on clean water.[8]

Near Chinese coal-fired power plants, tomato mercury reached 71.8-76.3 µg/kg at the closest sites against 0.73 µg/kg in a grocery-store sample.[4] In Seville, tomatoes from gardens in a mining district held less lead than city-garden tomatoes (89 against 165 µg/kg dry weight).[24]

Dry-weight results are about 17 times the fresh-weight concentration, and several papers report values that conflict with their own methods.[11,15,16] This page shows those values with the reason and does not compare them.

Yes. Baking tomato in foil raised aluminum about four-fold, and acidic tomato and meat dishes leached more aluminum from foil as acidity rose.[32,35] Simmering tomato sauce with new stainless steel raised nickel and chromium sharply, an effect that faded after several cooking cycles.[7]

Fresh Czech tomatoes held 80 µg/kg aluminum before cooking, about 1,700 µg/kg on a dry-weight basis.[32] Aluminum is not limited in fresh vegetables by the EU or Codex instruments verified here.[2,31,18]

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STATUS AND LICENCE

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DATA AVAILABILITY

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

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.

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