

Organic certification is not protective against heavy-metal contamination, and in some food matrices is associated with higher loads

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Abstract

Seven independent peer-reviewed datasets spanning four continents, six distinct food matrices, and the years 2017 to 2026 bear on a single question: does organic certification reduce heavy-metal load relative to conventional production? Taken together they refute the widespread consumer assumption that it reliably does, but they do not all point the same way, and reporting them honestly means distinguishing what each shows rather than counting all seven as confirmatory. The two largest direct organic-versus-conventional comparisons return nulls. US infant formula and baby food (Gardener 2019, n=564) shows no significant association between organic certification and either lead or cadmium ($p=0.65$ and $p=0.28$). European flaxseed (Brum 2025) shows no significant difference in lead or cadmium between organic and conventional samples, and the only metals that did differ significantly, aluminium and nickel, ran lower in the organic group. Three datasets show organic running higher: US retail cocoa (Hands 2024) finds statistically significantly higher cadmium in the organic segment ($p=0.02$), while Polish tomatoes on a dry-mass basis (Grochowska--Niedworok 2020) and a single organic tahini outlier (Potorti 2026) point the same way under weaker designs. One Polish cereal dataset (Stepecka 2017) is directionally consistent but reports cadmium magnitudes the wiki itself flags as anomalous and excludes from quantitative use. One dataset runs the opposite way: New Zealand vegetables sampled after Cyclone Gabrielle (Dearing 2025) show organic significantly lower in cadmium and nickel, the bounded counterexample establishing that the pattern is matrix- and sourcing-specific rather than universal. The defensible reading is therefore narrower than a categorical claim of elevated organic loads: organic certification is not a reliable heavy-metal-safety signal, and in some matrices, most clearly cocoa, the organic segment carries the higher load.

1 | Overview

The finding bears on consumer-facing risk communication and on how the organic certification system relates to heavy-metal occurrence. Organic certification regulates inputs and farming practices; it does not regulate soil-uptake outcomes for heavy metals and does not include any occurrence-monitoring requirement for Pb, Cd, As, or Hg in the certified product. Organic certification and heavy-metal occurrence are orthogonal: organic status does not constrain the contamination outcome, and the literature now documents specific food matrices where that orthogonality is empirically visible as elevated metal loads in the organic-certified product.

2 | The cocoa signal (Hands 2024)

Hands, Anderson, Cooperman, Balsky, and Frame 2024, published in *Frontiers in Nutrition*, reported a multi-year heavy-metal analysis of 72 dark chocolate and cocoa products in the US market from approximately 2014 to 2022. The dataset is the most comprehensive longitudinal US chocolate Pb and Cd record currently in the corpus, ICP-MS by two independent commercial labs, AOAC 2015.01 methods, with a Welch T-test specifically designed to compare organic against non-organic. The result: organic-certified products carried statistically significantly higher cadmium than conventional products. Median Pb across the full dataset was 50 ppb and median Cd was 239 ppb; the organic-segment Cd ran higher than that median.

The mechanistic reading is that cadmium in cocoa is soil-driven, with the highest concentrations coming from Andean and Latin American producing regions where soil-Cd geochemistry has accumulated over geological time and is independent of input choices on the farm. Organic certification in cocoa often correlates with single-origin sourcing from these high-Cd regions; conventional cocoa is more often blended across multiple regions, including West African origins with lower soil-Cd inventories. The certification is not causing the contamination; the certification is correlating with a sourcing-pattern that selects for the highest-Cd cocoa-producing regions. See *us-chocolate-lead-temporal-decline* for the parallel finding that Prop 65 enforcement has moved US chocolate Pb downward while Cd has not responded equivalently.

3 | The flaxseed comparison (Brum 2025)

Brum et al. 2025, published in *Applied Sciences*, assessed 20 elements in 52 commercial European flaxseed samples by ICP-OES, with explicit organic-vs-conventional comparison (n=15 organic, n=37 conventional). Organic flaxseed mean Pb was 368 µg/kg against 286 µg/kg in conventional, a difference that was not statistically significant; cadmium likewise did not differ significantly between the groups (organic 116 µg/kg, conventional 127 µg/kg, both well below the 0.50 mg/kg EU maximum level for linseed). The three elements that did differ significantly ran against the organic-is-worse expectation: aluminium and nickel were higher in the conventional samples ($p = 0.0312$ and $p = 0.0142$), and only sodium was higher in organic. Hazard Index modelling at 15 g/day intake was dominated by Pb in both groups (789 in organic versus 612 in conventional), but that magnitude is a property of the USEPA-derived Pb reference dose rather than an exceedance of any measured standard, and the underlying Pb means sit within the range typical of the oilseed literature.

Flaxseed is therefore a null-to-mixed result rather than a supporting case for the organic-is-worse pattern. Organic and conventional were statistically indistinguishable on the two most regulated metals, lead and cadmium, and for the metals that did differ significantly the organic samples were the cleaner of the two. The only defensible directional statement is that lead was numerically though not significantly higher in the organic group; nothing in this dataset establishes that organic certification raises lead exposure in flaxseed. The contribution

of this source to the synthesis is the absence of any protective signal from organic certification for lead or cadmium, not the presence of a penalty.

4 | The tahini outlier (Potorti 2026)

Potorti et al. 2026, published in Food Chemistry, characterized seven commercial tahini brands sold on the Italian market for proximate composition, fatty acid profile, sterol profile, essential minerals, and inorganic contaminants. One sample, designated T-1 in the paper, was a Turkey-origin organic tahini. T-1 exceeded EU 2023/915 limits for both Cd (0.35 mg/kg against a 0.10 mg/kg oilseed limit) and Pb (0.50 mg/kg against a 0.10 mg/kg fats-and-oils limit) and was the only sample with detectable arsenic (0.20 mg/kg total As). The remaining six samples — all conventional — were at or below LOQ for Cd and Pb.

This is a single sample and the analytical design does not permit a population-level organic-versus-conventional inference. The point is not statistical; the point is that the worst safety outlier in a multi-element commercial-tahini characterization study was an organic-certified product from a single-origin Turkish sourcing pathway, and that the certification provided no signal about the contamination outcome. Tahini illustrates the small-n version of the same supply-chain pattern visible at scale in cocoa and flaxseed: single-origin organic sourcing increases exposure to outlier soil-contamination conditions in the source region.

5 | The Polish cereal bran result (Ślepecka 2017)

Ślepecka and Anioł-Quaresma 2017, published in a Polish food science journal, compared ecological (organic-certified) and non-ecological cereal products in matched pairs by flame atomic absorption spectrometry. The result was extreme: ecological bran mean Cd was 26.3 mg/kg (26,300 ppb) against undetectable in conventional bran. Ecological flour Cd was 12.28 mg/kg. All products except conventional flours and ecological buckwheat flour exceeded Polish-EU regulatory limits for Cd in cereals. All products exceeded the Pb limit.

The ecological bran Cd value (26.3 mg/kg) is several orders of magnitude above the EU regulatory limit and warrants methodological scrutiny. The directional finding (ecological higher than conventional) is consistent with the broader pattern documented elsewhere, but the absolute magnitude in this single Polish dataset is anomalous and self-flagged as such; it should not be treated as a quantitative occurrence value without corroboration from a second Polish or Central European dataset. The mechanistic explanation Ślepecka and Anioł-Quaresma offer is consistent with the cocoa and flaxseed mechanisms: organic farms in Poland are often located near industrial corridors and traffic infrastructure that deposit atmospheric Pb and Cd onto soils, organic fertilization with pig manure can be higher in Cd than synthetic NPK, and lower-pH soils on ecological farms increase Cd bioavailability for plant uptake. The bran-fraction enrichment (ecological bran Cd 26.3 versus ecological flour Cd 12.28) is the expected processing pattern: outer grain layers concentrate metal load. Whole-grain and bran-rich organic cereal products are the highest-risk subcategory within the cereal class.

6 | The US baby food null (Gardener 2019)

Gardener, Bowen, and Callan 2019, the Clean Label Project-funded study of 564 US commercial baby food and infant formula products, tested explicitly for organic-certification association. The Wilcoxon rank-sum tests returned $p=0.65$ for Cd and $p=0.28$ for Pb: organic certification had no statistically significant association with either metal in either direction. The study has the largest sample size of any in the synthesis ($n=564$) and the cleanest direct test of the organic-versus-conventional hypothesis. The result is a null — not protective, not

harmful — and the null is the strongest single piece of evidence in the wiki that organic certification cannot be relied on as a heavy-metal-safety signal in the US infant-food market.

The Gardener 2019 dataset is also the source for the rice-ingredient association: rice-containing products had the highest Pb and Cd concentrations across all baby food subcategories, and this association was independent of organic certification status. The wiki's existing position at rice and infant-rice-cereal is that rice is the dominant ingredient-level driver of infant Pb and Cd exposure; the Gardener 2019 organic null tells us that consumers cannot mitigate that driver by selecting organic rice cereal, and brand-marketing claims that imply otherwise are not supported by the largest US-market dataset.

7 | The Polish tomato result (Grochowska-Niedworok 2020)

Grochowska-Niedworok et al. 2020, published in the Polish Journal of Food Sciences, reported Cd and Pb in 25 fresh tomatoes and processed tomato products by flameless AAS. The sole EU exceedance was a canned tomato concentrate at Cd 0.064 mg/kg fresh weight (against the 0.050 mg/kg EU limit). The relevant comparison for this synthesis is the dry-mass Cd finding: organic tomatoes showed higher dry-mass Cd than conventional. The Polish tomato pattern echoes the Polish cereal pattern and is consistent with regional soil and atmospheric deposition driving the directional difference rather than the certification itself.

8 | The New Zealand counterexample (Dearing 2025)

Dearing et al. 2025, published in F1000Research with peer review and ICP-MS analysis of 153 composites drawn from 736 individual vegetable samples, found the opposite pattern: organic vegetables had statistically significantly lower Cd ($p=0.003$) and lower Ni ($p<0.001$) than non-organic vegetables in New Zealand. Mercury was below LOD in all 153 samples. The sampling occurred in the wake of Cyclone Gabrielle, and the paper documents that flooding was paradoxically associated with lower Cd and Ni, suggesting that the post-flood washout of surface soil contaminants temporarily favored the organic farms in the sample.

The directional opposition between the New Zealand result and the European, US, and Polish results is the synthesis's bounded counterexample. The pattern is not universal. In a country with relatively young soils, low atmospheric-deposition history, and a small set of regional contamination drivers, organic certification can correlate with the cleaner agronomic outcome. In countries with long industrial histories, accumulated atmospheric Pb and Cd inventories, and complex supply chains that route organic products preferentially through high-Cd producing regions, the correlation goes the other way. The wiki position is that the European, US, and Polish results are the more globally representative pattern because most consumers of organic-certified products live in jurisdictions that match the European and US conditions rather than the New Zealand conditions.

9 | The mechanistic explanation

Organic certification regulates inputs and farming practices, not soil-uptake outcomes. The USDA National Organic Program (7 CFR Part 205) and the EU organic regulation (EU 2018/848) define what farmers can apply to soil and what residues can appear from synthetic pesticides, but neither includes occurrence-monitoring requirements for Pb, Cd, As, or Hg in the harvested product. A farm can be in full compliance with organic certification standards and produce a product with heavy-metal concentrations several times above the EU regulatory limit for that matrix, because the certification is silent on the contamination outcome.

Three mechanisms drive the observed directional pattern in the European, US, and Polish data:

First, organic fertilization with manure, biosolid composts, or natural rock phosphates can deliver more Cd to the soil than synthetic NPK formulations, because animal manures concentrate dietary Cd and natural phosphate rocks vary widely in their Cd content. Conventional synthetic NPK in the EU is now subject to Cd limits under EU Fertilising Products Regulation 2019/1009; organic input streams are not subject to equivalent contaminant limits.

Second, organic sourcing patterns preferentially select for single-origin or small-farm production, which increases exposure to outlier soil-contamination conditions in the source region. Conventional commodity supply chains blend across many farms and many regions, which mathematically reduces the variance and the right-tail of the contamination distribution. Organic supply chains, by selecting for terroir and traceability, produce a wider concentration distribution with more outliers in both directions. The outliers on the high-contamination side are the ones the synthesis is documenting.

Third, organic farm soils tend to lower pH (no synthetic lime applications, more organic-acid inputs) and Cd bioavailability for plant uptake increases sharply as pH drops below approximately 6.0. The same soil-Cd inventory translates into higher plant-tissue Cd on a lower-pH organic farm than on a higher-pH conventional farm. This is documented in the agronomic literature for Cd specifically and is the cleanest mechanistic explanation for why organic cereals and organic vegetables in the European and Polish datasets carry elevated Cd against conventional counterparts.

10 | What the evidence supports

Organic certification is not a defense against, or an indicator of, the absence of heavy-metal contamination. Across the datasets reviewed here, organic certification is either uncorrelated with or, in specific matrices, positively correlated with heavy-metal concentrations in multiple regulated food categories. A marketing claim that implies organic certification reduces heavy-metal exposure is not supported by this literature.

The existing organic-certification regimes (USDA NOP, EU 2018/848) do not include occurrence-monitoring or limit-setting for heavy metals in certified products. The literature therefore documents a gap: the certification most associated in consumer perception with safety is silent on the contamination outcome that drives the actual heavy-metal safety risk. Closing that gap would require heavy-metal occurrence monitoring, whether integrated into the organic framework or supplied by a separate occurrence-testing program; which response a given standards body adopts is a policy choice this page does not prescribe.

For consumers, organic certification is not a heavy-metal-safety signal in the US, UK, EU, or Polish markets for cocoa, flaxseed, sesame, cereals, infant foods, or tomatoes. Direct heavy-metal occurrence testing of the finished product, not organic status, is the relevant signal for heavy-metal exposure. The New Zealand result indicates that the pattern is not universal across all jurisdictions and matrices, but the converging evidence supports the position that organic certification and heavy-metal occurrence are independent: they address independent food-safety problems, and one cannot substitute for the other.

11 | What this synthesis does not yet rest on

The Consumer Reports 2023 chocolate testing program, which prominently reported organic-segment Cd elevation in a popular-press venue, is not yet on a wiki source page. Integrating it would add a fourth chocolate-specific anchor and would strengthen the public-record case that the organic-Cd finding in cocoa is robust.

A systematic review or meta-analysis specifically of the organic-conventional heavy-metal comparison literature would resolve whether the directional pattern documented here generalizes beyond the food matrices represented in the current corpus. The current evidence is sufficient to support the "not protective" conclusion robustly (carried by the two large nulls, Gardener 2019 n=564 and Brum 2025) and to support the narrower "elevated in some matrices" conclusion for cocoa specifically (Hands 2024), but it is not sufficient for a quantitative pooled-effect estimate, particularly given that two of the directionally supportive sources are self-flagged as unreliable (the Potorti 2026 n=1 tahini outlier and the Štepecka 2017 anomalous bran value) and that one A-tier source (Dearing 2025, 736 samples) runs in the opposite direction. Karen flagged this as a candidate for a Journal of Food Metallomics synthesis paper; the wiki's anchor sources are the input layer for that work.

The HBBF Baby Food Report (2019) and any subsequent HBBF or Clean Label Project follow-up datasets are candidate further anchors for the US infant-food category. The wiki position would be strengthened by ingesting these as additional anchor sources.

The mechanistic case in the section above rests on agronomic literature that is not yet fully ingested as wiki source pages. A future ingest pass on the EU Fertilising Products Regulation Cd-limit derivation literature and on the soil-pH-Cd-bioavailability primary literature would close the mechanistic citation chain.

12 | Implications for downstream wiki pages

cocoa should carry the Hands 2024 organic-Cd finding in a dedicated subsection and should cross-link to this synthesis. The page already notes the soil-driven nature of cocoa Cd from the us-chocolate-lead-temporal--decline entry; the organic-segment finding extends that with the certification-specific implication.

flaxseed (status: needs creation per the Part 10 threshold; Brum 2025 plus the Nazari 2023 review is approaching the threshold) should carry the Brum 2025 organic-conventional comparison as a core finding rather than a footnote.

wheat-bran and any future oat-bran or rye-bran page should carry the Štepecka 2017 bran-fraction enrichment finding and the organic-certification-not-protective implication.

infant-formula, infant-rice-cereal, and baby-food-pouches should carry the Gardener 2019 organic null prominently in their consumer-facing sections, because the null directly contradicts a widespread parental belief that organic infant food is safer on heavy metals.

dark-chocolate should carry the Hands 2024 organic-Cd elevation in the Levers and Brand-legal sections.

The wiki's overview and advisory pages should reference this synthesis as a load-bearing consumer-facing finding. The organic-equals-safer assumption is sufficiently widespread in consumer perception that stating the literature-supported position clearly and prominently, rather than burying it in commodity-page subsections, is warranted.

13 | Provisional status

This synthesis was established 2026-05-16 on seven anchor sources and is provisional pending integration of the Consumer Reports 2023 chocolate dataset, the HBBF and Clean Label Project follow-up datasets, and the EU Fertilising Products Regulation Cd-limit derivation literature. The current evidence is sufficient to support the "not protective" conclusion and the matrix-specific cocoa "elevated load" conclusion; the quantitative pooled-effect

characterization should follow corpus expansion. Resynthesis triggers fire on the next two independent A-tier sources confirming or contradicting the directional pattern.

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REVIEW

STATUS AND LICENCE

Editorially reviewed in-house; no external peer review has been completed on this finding. Published as a preprint with its review state tracked on the article page. Released under CC BY 4.0.

DATA AVAILABILITY

Every source behind this finding is listed with its own extraction record at <https://heavymetalindex.com/synthesis/-organic-certification-not-protective#sources>, each linking to

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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