

Tin (Sn) — HMTc analyte

Karen Pendergrass · ORCID 0000-0002-2348-7259

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THE ANALYTE

50 · Sn · Total elemental tin

Inorganic tin migrating from tinplate cans produces only an acute gastrointestinal effect, with a wide margin between regulated canned-food concentrations and the dose that reliably irritates the gut in controlled human challenge, so its maximum level functions chiefly as a sentinel for can-lining integrity rather than a guard against chronic or cumulative toxicity.

Why it is limited

The government and expert-body assessments that underpin limiting tin in food, and what each concluded. The maximum levels in force apply these findings; this page is the rationale, not the certification threshold.

BODY	YEAR	ASSESSMENT	WHAT IT CONCLUDED
ATSDR	2005	Toxicological Profile for Tin and Tin Compounds (Harper, Llados, Diamond, Chappell et al.)	Inorganic tin is poorly absorbed (about 5 percent, over 90 percent fecal excretion) and acts through local gastrointestinal irritation rather than systemic accumulation. ATSDR derived an intermediate-duration oral MRL of 0.3 mg/kg/day for inorganic tin and a chronic oral MRL of 0.0003 mg/kg/day for tributyltin oxide — a roughly thousand-fold (three-order-of-magnitude) separation between the inorganic and organotin classes that establishes why only the inorganic species drives the canned-food limit.
Peer-reviewed human toxicology (Benoy, Hooper & Schneider)	1971	The Toxicity of Tin in Canned Fruit Juices and Solid Foods, Food and Cosmetics Toxicology 9(5):645-656	Controlled human single-dose challenges established the robust acute symptomatic gastrointestinal threshold for ingested inorganic tin at approximately 1,000 to 1,400 ppm (mg/kg) in canned fruit juices — the empirical dose-response that underlies the regulatory acute-GI endpoint and sits well above every jurisdiction's canned-product cap.
JECFA (basis for Codex CXS 193-1995 tin MLs)	1995 (Codex ML); JECFA 33rd meeting (1989)	Codex General Standard for Contaminants and Toxins in Food and Feed (CXS 193-1995), tin maximum levels; underlying JECFA evaluation of tin (33rd meeting)	Codex sets 250 mg/kg for canned foods other than canned beverages and 150 mg/kg for canned beverages, both grounded in the acute-GI critical endpoint rather than any chronic or carcinogenic effect. The JECFA provisional tolerable weekly intake of 14 mg/kg body weight (converted from a PMTDI of 2 mg/kg/day at the 33rd meeting), and the finding that concentrations near 150 mg/kg in beverages and 250 mg/kg in other canned foods can provoke gastrointestinal irritation in some sensitive individuals, are the toxicological anchors for these Codex values.

BODY	YEAR	ASSESSMENT	WHAT IT CONCLUDED
European Commission (EU 2023/915)	2023	Commission Regulation (EU) 2023/915 on maximum levels for certain contaminants in food, tin provisions 3.5.x	The EU sets the strictest published canned-food tin caps — 200 mg/kg in canned food other than beverages, 100 mg/kg in canned beverages, and 50 mg/kg in canned infant formula, follow-on formula, young-child formula, and canned baby/processed-cereal foods. The infant/young-child cap is deliberately one-quarter of the general canned-food cap, a precautionary reduction reflecting body-weight-normalized intake in the vulnerable infant population.
IARC	n/a	IARC Monographs — carcinogenicity classification status of tin and inorganic tin compounds	IARC has not evaluated inorganic tin — no IARC monograph assigns it a carcinogenicity group. The regulated endpoint is acute gastrointestinal irritation, not cancer; the absence of any carcinogenicity or genotoxicity basis is what keeps tin a high-margin, acute-only analyte rather than a zero-tolerance toxic.
Peer-reviewed regulatory-toxicology review (Schafer & Femfert)	1984	Tin — A Toxic Heavy Metal? A Review of the Literature, Regulatory Toxicology and Pharmacology 4:57-69	Established, in the European regulatory-toxicology literature, the inorganic-versus-organotin species-distinction principle — that total-tin measurement without speciation cannot be mapped honestly to toxicity-derived guidance because the two classes differ by orders of magnitude. This is the rationale for treating a total-elemental-tin result in canned matrices as inorganic-tin context.

Toxicological basis

What the assessment bodies found when they examined inorganic tin, and why a canned-food limit exists despite a wide margin of safety: the acute endpoint that anchors regulation, the narrow population it reaches, and the carcinogenicity question that, for tin, has no answer to give.

The endpoint that anchors every tin limit is acute, local, and reversible. Inorganic tin, the stannous (Sn²⁺) and stannic (Sn⁴⁺) forms that dissolve from a tinplate lining into acidic canned food, is poorly absorbed: roughly 5 percent is taken up from the gut and more than 90 percent is excreted in the feces, so it does not build a systemic body burden the way [lead](#) or [cadmium](#) do. Its toxic action is direct irritation of the gastric and intestinal mucosa, producing nausea, vomiting, and diarrhea. Controlled single-dose human challenges placed the robust symptomatic threshold at approximately 1,000 to 1,400 ppm (mg/kg) tin in canned fruit juice, and ATSDR derived an intermediate-duration oral minimal risk level of 0.3 mg Sn/kg body weight per day from a stannous-chloride NOAEL of 32 mg/kg/day with a hundredfold uncertainty factor. The distinguishing fact about tin, stated plainly, is that the regulated canned-food caps sit well below the concentration that reliably irritates the gut; the limit is precautionary headroom, not a line drawn at the effect level.

The population that regulation reaches is narrow and the concern is bounded. Because tin occurrence is a packaging phenomenon rather than an intrinsic property of food, the exposed group is whoever eats acidic products from tinplate cans: canned tomato products, fruit and fruit juice, pickled vegetables, and canned beverages, with the dissolution rate governed by content acidity, the presence or absence of an internal lacquer, oxygen, and storage time and temperature. Infants and young children fed canned baby food are the one group given specific protection, because intake normalized to body weight is far higher in a small child; [EU 2023/915](#) sets the canned infant and young-child limit at 50 mg/kg, one-quarter of the general canned-food cap. Even there the concern is a single acute

gastrointestinal event rather than a cumulative burden. The chronic effects identified in the supporting animal literature, anemia and reversible liver and kidney changes, appear only at sustained doses far above any realistic dietary intake.

On carcinogenicity, precision means acknowledging an absence. IARC has never evaluated inorganic tin; no monograph assigns it a carcinogenicity group, and the regulatory record identifies no genotoxic, carcinogenic, developmental, or reproductive endpoint on which a limit could rest. This is the honest opposite of the [nickel](#) or cadmium case, and it is worth stating rather than blurring. The one place tin toxicology turns serious is a structurally separate class: the organotin compounds, tributyltin and its relatives, are lipophilic, well absorbed, and immunotoxic, neurotoxic, and reproductively toxic at exposures roughly three orders of magnitude lower, reflected in ATSDR's chronic oral MRL of 0.0003 mg/kg/day for tributyltin oxide against 0.3 mg/kg/day for inorganic tin. But organotins arise from seafood and PVC contact materials, not from the tinplate-can pathway, and they are not what a total-elemental-tin certification measure in canned food is detecting.

These readings converge. ATSDR, the JECFA evaluation that underlies the Codex maximum levels, the European Commission in EU 2023/915, and EFSA's tolerable-upper-intake opinion all anchor tin regulation on the same acute gastrointestinal endpoint, and none invokes a chronic, cumulative, or carcinogenic basis; the numbers differ only in conservatism, with Codex at 250 and 150 mg/kg for canned foods and beverages and the EU tighter at 200 and 100 mg/kg. Tin's absence from other registers is itself informative: no jurisdiction has found a carcinogenic or reproductive-toxicity basis to list it, and it does not appear on California's [Proposition 65](#) roster, while the United States sets no food action level for tin at all. What this leaves is a limit that functions as a sentinel; an elevated total-tin result flags a corroding, under-lacquered, or over-stored can, a packaging-integrity signal rather than a systemic health hazard. The science came first, and the limits followed it honestly, including where the science declined to find a chronic hazard to guard against.

Occurrence & exposure

How much tin food actually carries, and how the regulated caps relate to the dose that produces an effect. Tin occurrence is a packaging story rather than a food story, and the numbers separate cleanly along that line; the complete occurrence corpus is on the Heavy Metal Index.

Tin by food matrix, compiled on the Heavy Metal Index from ATSDR 2005 (Biego et al. 1999 survey data, Tables 6-2/6-3) and canned-beverage measurement studies (Tarigan et al. 2016). Values are mg/kg wet weight. These are population occurrence values, not safety thresholds; tin occurrence tracks the can rather than the food, so the same product can read orders of magnitude apart in a lacquered versus an unlacquered container.

FOOD MATRIX	CONDITION OR FORMAT	REPORTED TIN (MG/KG)
Canned fruit & vegetables	unlacquered / mixed cans (survey)	24–156
Canned food, general	unlacquered cans	up to 100
Canned food, general	lacquered cans	below 25
Canned beverages	carbonated, beer, juice	2.5–5.8

FOOD MATRIX	CONDITION OR FORMAT	REPORTED TIN (MG/KG)
Canned alcoholic beverages	—	~4.5
Non-canned foods	not metal-packaged	below 2
Meat, milk, dairy, bread, pasta	non-canned staples	≤0.003

Regulated canned-food tin caps set against the doses that produce an effect, showing the margin that makes a tin maximum level a can-integrity sentinel rather than a health threshold. Values are mg/kg; these are regulatory limits and reported effect concentrations, not occurrence data.

REFERENCE POINT	TIN CONCENTRATION (MG/KG)	BASIS
Historical poisoning outbreaks	250–7,300	Benoy 1971 (1967 Kuwait to 1890 canned cherries)
Robust acute-GI threshold, controlled human challenge	1,000–1,400	Benoy 1971
GI effects reported in sensitive individuals	150–250	JECFA evaluation (beverages / other canned foods)
Codex maximum level, canned food (non-beverage)	250	CXS 193-1995
EU maximum level, canned food (non-beverage)	200	EU 2023/915
Codex / EU maximum level, canned beverages	150 / 100	CXS 193-1995 / EU 2023/915
EU maximum level, canned infant & baby food	50	EU 2023/915

The pattern in the occurrence data has a single driver, which is contact between food acid and an exposed tin surface. Light-colored fruits and juices were historically packed in unlacquered tinplate precisely because dissolved tin reacts with anthocyanin pigments and preserves product color, which is why that category sits at the top of every survey. Modern lacquered linings interrupt the food-to-tin reaction, and the great majority of cans now carry them, which is why routine canned product reads far lower than the historical record and why anything outside a metal can, whether fresh, frozen, glass-packed, or pouched, carries only trace tin indistinguishable from background.

The reason to measure tin at all is therefore not that the food is intrinsically hazardous but that an elevated result is diagnostic. Rising tin signals a corroding, under-lacquered, or over-stored can, and it is that packaging failure, rather than a chronic toxicological threat, that the maximum level is built to catch before it approaches the range at which the most sensitive individuals report gastrointestinal effects. For the certification program the value is a sentinel of supply-chain and packaging control — tin is a claim analyte equal at the gate with every other published limit; the acute, reversible, high-margin nature of the endpoint is why it is carried as a packaging sentinel rather than as a chronic toxicant.

Anchor dataset: ATSDR 2005 Toxicological Profile for Tin and Tin Compounds (A-tier US government report), carrying the Biego et al. 1999 by-matrix occurrence survey; corroborated by Tarigan et al. 2016 (canned beverages, B-tier) and the Benoy et al. 1971 controlled human-challenge dose-response (A-

tier). Regulatory caps from EU 2023/915 and [Codex CXS 193](#)-1995. The full occurrence corpus is on the [Heavy Metal Index](#)².

How it is regulated

Binding maximum levels are concentration caps on canned product. EU 2023/915 sets the strictest published caps (200 mg/kg canned food other than beverages, 100 mg/kg canned beverages, 50 mg/kg canned infant/baby foods and formulas) and generally governs; Codex CXS 193-1995 is looser (250 and 150 mg/kg, JECFA-derived). The US FDA sets no action level for tin in food, addressing it instead through Total Diet Study surveillance and food-contact-material guidance — so where the strictest sovereign limit must be found for a non-canned or infant product, the standard reads across from the nearest government value rather than inventing one. In the HMTc infant-and-child-food standards the binding value is the strictest government ML converted to the row's native basis (for example, India [FSSAI](#) binds the teething-and-snacks Sn row at 5,000 µg/kg as-sold). See the cert /regulations/ derivation pages — eu-2023-915, codex-cxs-193, india-fssai, and us-fda-c2z — for the side-by-side sovereign comparison; the standard pages, not this page, carry the full number set.

How the HMTc program treats it

Tin is a claim analyte, certified as "total elemental tin", held to the government limit with no allowed overage — a treatment consistent with its acute-only, high-margin, non-cumulative gastrointestinal endpoint, and equal at the gate with every other published limit. A product above the limit enters Remediation unmarked. No speciation trigger applies to tin in the certification program: unlike [arsenic](#) (reflex to iAs), [mercury](#) (MeHg), or [chromium](#) (reflex hexavalent-chromium speciation on total-Cr above 100 ppb), tin is measured and limited as total elemental tin. Its operational role is a sentinel for packaging and can-lining integrity — an elevated total-tin result flags a corroding, under-lacquered, or long-stored can rather than a systemic health hazard. Grounded in standards/teething-and-snacks.md (HMTc limit 5,000 ppb bound by India FSSAI) and the infant-and-child-foods.md manual method note.

Literature baseline

The complete peer-reviewed and regulatory literature for tin is maintained independently at the [Heavy Metal Index](#)². That reference reports what the literature says; this certification site applies it. The two are kept editorially separate by design.