

Are Tea and Coffee Good for You

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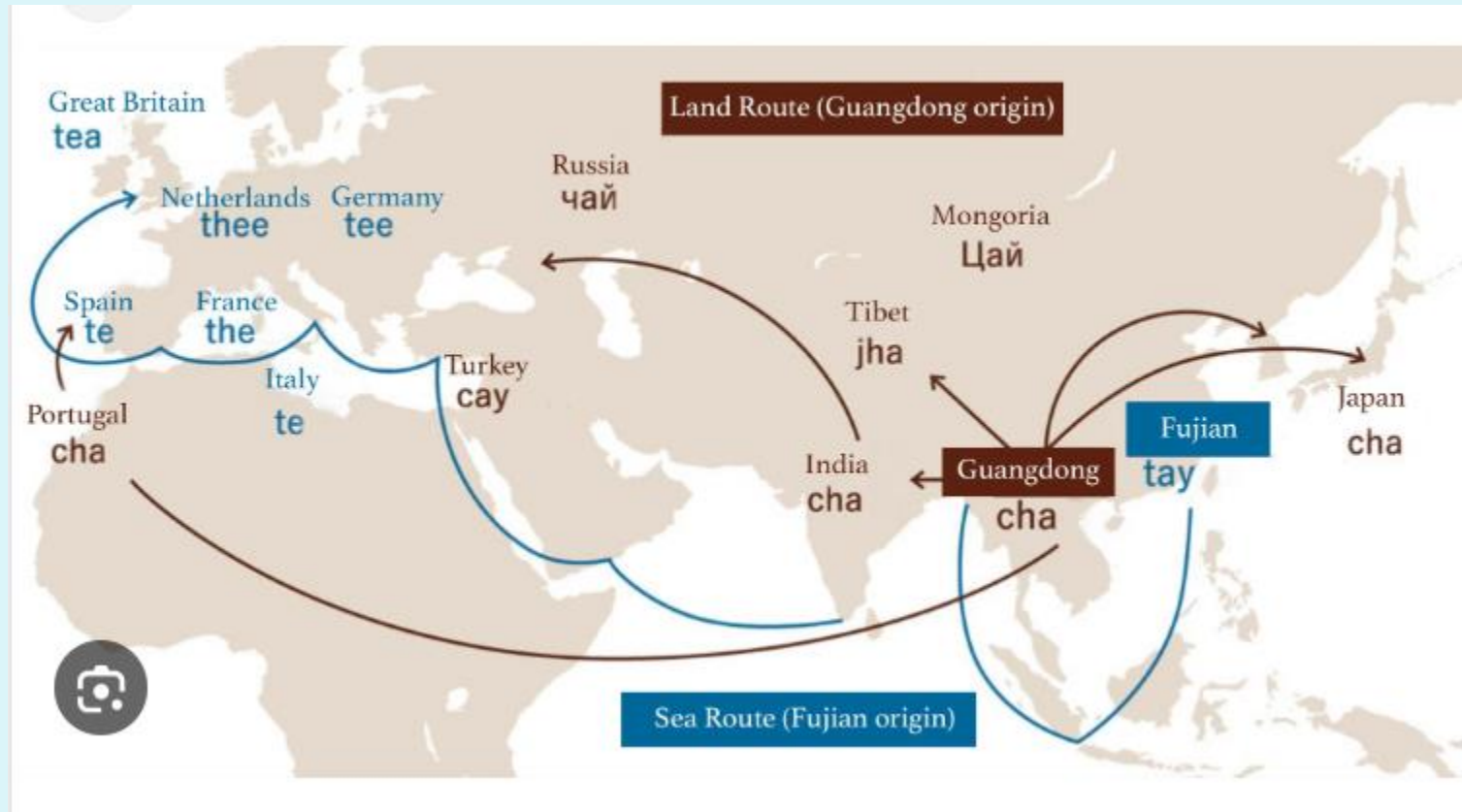


神农尝百草的传说

- **时间**：约公元前2737年（传说中的神农时代）
- **故事** 有一天，他在野外煮水时，几片树叶偶然飘入锅中，神农喝下后，觉得口感清新、精神振奋
- **16世纪**：葡萄牙和荷兰商人将中国茶叶带到欧洲。
- **17世纪**：英国。
- **19世纪**：英国人在印度和斯里兰卡大规模种植茶叶，



Guangdong and Quanzhou



中国茶类大全



Camellia sinensis: 红茶 = Black tea; 黑茶 = Dark tea

Name Clarification

中文名	<i>international name</i>	Oxidation
中国红茶	<i>Black tea</i>	Fully
中国黑 茶	<i>Dark tea (post-fermented tea)</i>	Fully, continuous Aging is better
中国青 茶	<i>Oolong tea</i>	Partial
中国绿茶	Green tea	Non



Camellia sinensis vs Tisanes

- **Camellia sinensis** is the scientific name for the tea plant.
- "**Camellia**" refers to the genus of flowering plants in the family Theaceae
- "**Sinensis**" is a Latin term meaning "from China,"

Camellia sinensis (Tea)	Tisanes (not true tea)
Green	Herbal tea
Black	Rooibos (red tea)
Oolong	Peppermint
White	Chamomile
Yellow	Hibiscus
Pu-erh	

Key Differences Between Oxidation and Fermentation

Aspect	Oxidation	Fermentation
Definition	Chemical reaction with oxygen	Microbial breakdown of organic compounds
Process	Enzymatic (polyphenol oxidase)	bacteria , yeast, fungi. No oxygen is required.

Oxidation and Fermentation

Type	Oxidation	Fermentation	Key Characteristics
Green	Minimal	None	green color high in catechins and antioxidants.
Black	Full (80–100%)	None	Dark color . high in theaflavins and thearubigins (from fermentation)}
Oolong	Partial (10–70%)	None	Combination of green and black teas.
Dark Pu-erh	Minimal	Fully	Aging is better (Pu-erh)

	Green	Black	Dark
Harvest	young leaves	mature leaves	mature leaves
Withering 萎凋, 凉	2 hr or skipped.	Long 12–18 hr	(few hours).
Oxidation	No	Full.	No oxidation
Kill-Green	Steaming or pan-firing /enzymes.	No kill-green step	Kill-green via pan-firing or steaming.
Rolling/Sha ping	Rolled gently to shape	Heavily rolled to rupture cells.	Rolled loosely or compressed later.
Drying	Final drying (pan, oven, or sun).	Drying to halt oxidation/fermentation.	Sun-dried or baked.
Post-Processing	None	None	Fermentation Microbial , years
Packaging	Airtight, light-proof containers.	Bulk packaging or tea bags.	Compressed into cakes/tuo cha or loose.

Leaves are rolled to rupture cells, releasing enzymes.

Exposed to oxygen in a warm, humid environment for **2–4 hours** .

World wide tea consumption

Tea	Global %	Major Area	Origin
Green	20-25	China, Japan, Morocco, Vietnam, South Korea, Taiwan	China
Black	75-80	India, UK, Pakistan, Kenya, Turkey, Russia, USA, Egypt	Fujian
Oolong	2-3	China Taiwan, SE Asia, Japan	Fujian and Guangdong
White	<1	China, Japan, USA, EU (health markets)	Fujian
Yellow	<0.5	China (Hunan, Anhui, Zhejiang)	Hunan, Sichuan
Dark	1-2	China (Yunnan, Tibet), Mongolia, Malaysia, Western niche	Yunnan, Sichuan, Hunan

Common Chinese Tea

Oolong	大红袍, 铁观音
Black	金骏眉(红), 正山小种(红) 祁门红茶
Green	碧螺春, 龙井
Dark tea	Post-fermentation better if aged for years 普洱茶(熟普) 安化黑茶, 六堡茶

金骏眉, 正山小种, 本质上是黑茶, 但在中国民间被称为红茶, 产地在福建. 在中国民间叫做红茶的本质上都是黑茶.

Unlike fermentation, post-fermentation occurs **after the initial processing** of the tea leaves and continues during storage or aging.

No Large-Scale Human Studies: Pu-erh tea reduces mortality

Lab evidence of health benefits of Pu-erh

Cholesterol Reduction

Antioxidant Properties

Weight Management

Anti-Inflammatory Effects

Blood Sugar Regulation

Digestive Health

Liver Protection

Detoxification

Improved Cognitive Function



Aflatoxin in Pu-erh Tea

- Pu-erh's fermentation is done with specific microbes like *Aspergillus niger* and *Eurotium*, but if contaminated with *Aspergillus flavus* which produce carcinogenic Aflatoxin B₁
- Aflatoxin B₁ is produced by *Aspergillus flavus* and *Aspergillus parasiticus* 的致癌物，常见于受污染的花生、玉米、坚果和其他谷物中
- **Aflatoxin B₁** : EU and China limits for tea are typically $\leq 5 \mu\text{g}/\text{kg}$
- Chronic exposure to $>1 \mu\text{g}/\text{kg}/\text{day}$ may cause liver damage.
- Properly stored Pu-erh (dry, ventilated, $\leq 70\%$ humidity) minimizes toxin production.
- Poor storage (high humidity, $>75\%$) promotes mold growth (*Aspergillus* spp.), increasing toxin levels over time.

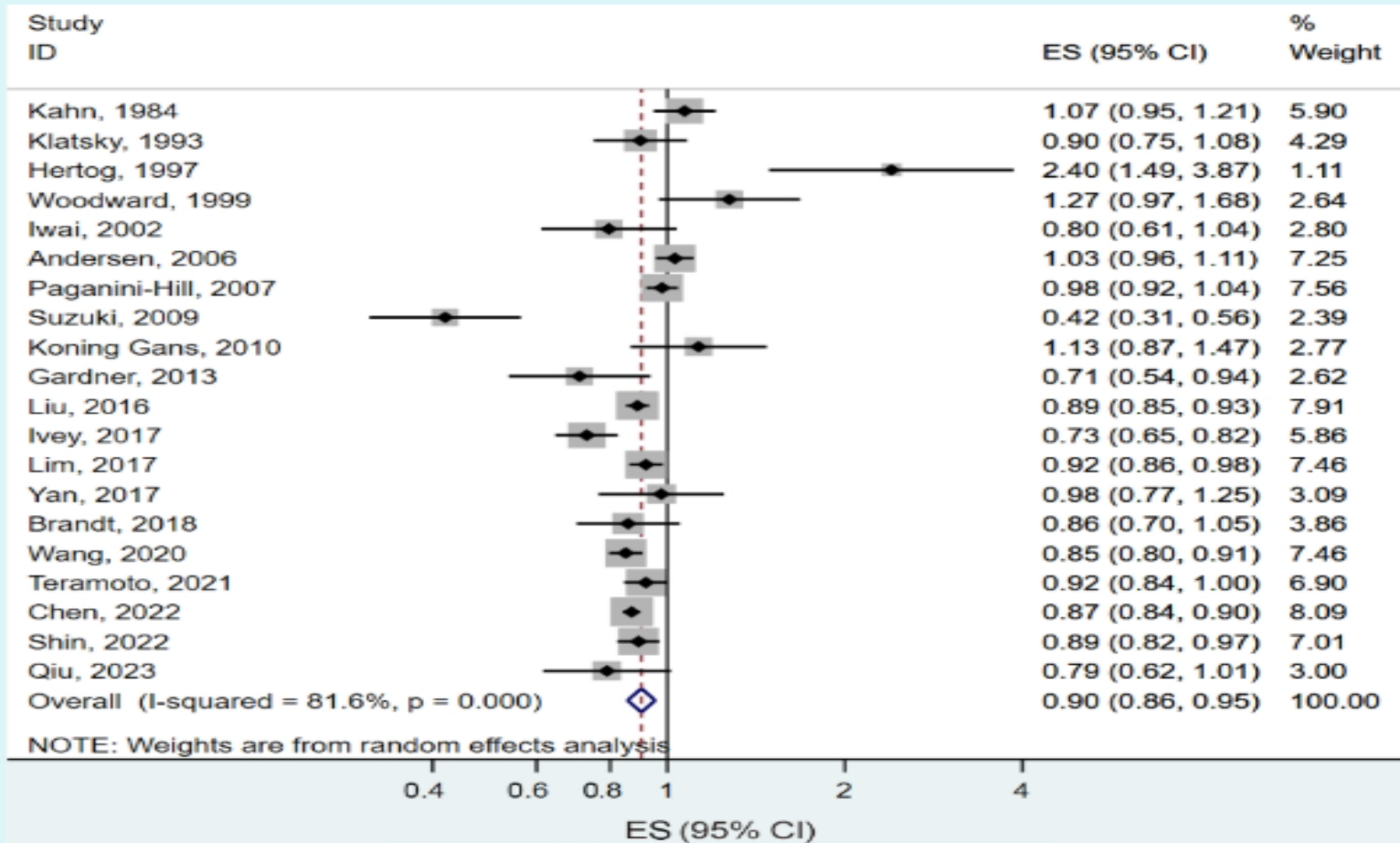
Toxin Levels in Pu-erh Tea by Storage Time

Storage	Aflatoxin B ₁ , mg/kg	Ochratoxin A mg/kg	Health Risk
2 years	0.5–5.0*	1.0–10.0*	Low to moderate risk if within regulatory limits.
5 years	1.0–10.0*	2.0–15.0*	Moderate risk; potential for toxin accumulation if stored improperly.
10 years	2.0–20.0*	5.0–25.0*	Higher risk; long-term storage increases mold growth if humidity/moisture are uncontrolled.

Pros/Cons of Clinical Studies

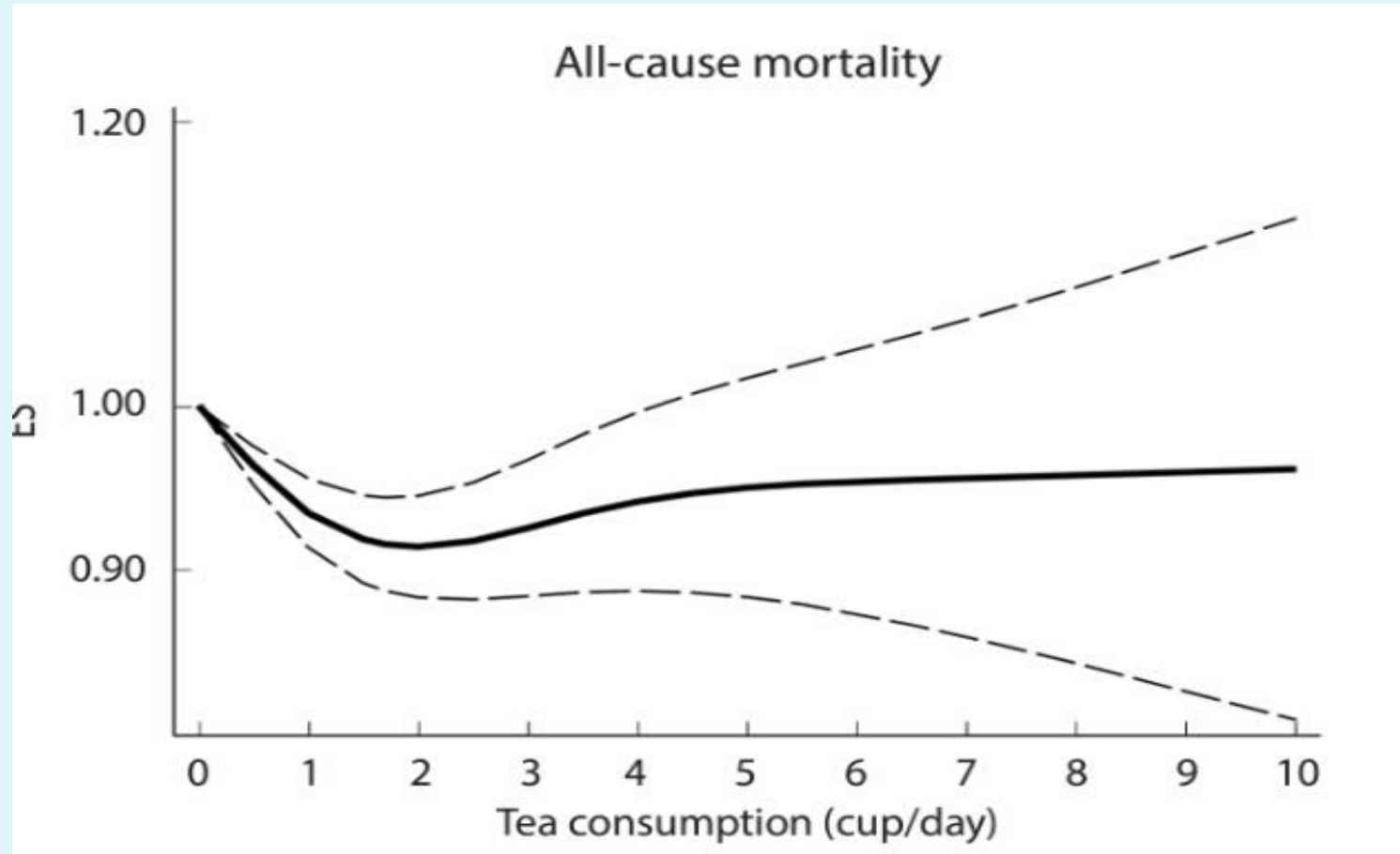
	Design	Pros	Cons
Retrospective Cohort	link past exposures to outcomes.	Quick/cheap rare outcomes.	recall/selection bias. confounders. No causality
Prospective Cohort	follows participants over time to track exposure→outcome.	Better than retro ↓ recall bias.	Time + cost. Loss to follow-up. Possible causality
Randomized Controlled	randomly assigns people to control vs intervention	Gold standard for causality. No confounding.	Cost, time Unethical, impossible
Meta-Analysis	multiple studies RCTs, retro/prosp cohort	↑ statistical power. Resolves conflicting evidence.	Garbage in, garbage out. Heterogeneity

Prospective cohort studies of all-cause mortality for any tea consumption. 1,956,549 participants



ES, effect estimate; CI, confidence interval. Epidemiol Health 2024;46:e2024056.

Tea consumption (cup/day) and mortality



Mortality benefit of tea: single large prospective clinical trials.

Rank		Mortality benefit	Hazard ratio	Study
1	Green Tea	Reduced all-cause, CVD, and cancer mortality	0.77 (> 5 cups)	164,681 participants
2/3	Oolong Tea	Reduced CVD mortality, particularly in men	0.39 (≥ 1 cup/day)	76,979 participants
2/3	Black Tea	Modestly reduced all-cause and CVD mortality	0.87	500,000 participants

No long term randomized trial available .

No large head to head prospective clinical trials

Limited large prospective studies for Oolong tea

Very limited large prospective studies for red tea (not tea)

Ann Intern Med. 2022;175(9):1201.

Benefit of Tea

- **All-cause mortality**
- **Cardiovascular disease, stroke**
- **Cancer** : reduce the risk of certain cancers (e.g., breast, prostate, and colorectal cancer).
- **Diabetes** : Improve insulin sensitivity and reducing the risk of type 2 diabetes.
- **Dementia**

Benefit in cardiovascular mortality, prospective large clinical trials.

Rank	Tea	HR	#
1	Green Tea (strong)	0.69	528504
2	Oolong Tea (limited)	0.39	76,979
3	Black Tea (moderate)	0.9	856,206

Green tea has the most extensive studies



Benefit in Cancer mortality, prospective large clinical trials.

Rank	Type	Hazard Ratio (HR) for Cancer Mortality	Study Population
1	Green	0.79 (> 5 cups/day), some ?	164,681
2	Black	0.90 (highest vs. lowest consumption)	498,043
3	Oolong	? Not specified	Not applicable



Benefit in dementia risk: Prospective large clinical trials.

Rank	Type	Key Findings	Hazard Ratio (HR) or Relative Risk (RR)	Study Population
1	Green	AD, and VD	RR = 0.71	410,951
2	Black T	AD	RR = 0.88	410,951
3	Oolong	cognitive impairment	Not specified	76,979

AD Alzheimer's dementia , VD vascular dementia



Summary: Associations Between Tea Consumption and Mortality

Tea Type	All-Cause Mortality	CVD Mortality	Cancer Mortality	Dementia
Green Tea	↓↓↓	↓↓↓	?↓	↓ limited
Black Tea	↓↓	↓↓	?↓	?↓ Limited
Oolong Tea	↓↓↓ Small studies	↓↓↓ Small studies	?↓ Limited	?↓ Limited

No randomized trial



Beneficial components in Tea

	Green	Black	Oolong	Function
Epigallocatechin gallate (EGCG)	High	Low	Moderate	Powerful antioxidant; reduces inflammation, supports heart health, aids in weight management, protects brain cells.
Catechins	High	Moderate	Moderate	Antioxidant properties; helps reduce oxidative stress, lowers cholesterol, improves cardiovascular health.
Theaflavins	Low	High	Moderate	Antioxidant; reduces cholesterol, improves blood vessel function, supports heart health.
Thearubigins	Low	High	Moderate	Antioxidant; anti-inflammatory, may help regulate blood sugar levels and improve gut health.

	Green	Black	Oolong
Antioxidants	Catechins	Theaflavins, Thearubigins	Catechins, Theaflavins
Antioxidant capacity	++++	++	+++
Dilation of brachial artery	Yes,	Yes	Yes
LDL	-11.5 mg/dL	-7.8 mg/dL	decreased
HDL	++	+	++
BP	-3.18/3.42	-1.85/1.27	decreased
Insulin sensitivity	Improved	Improved	improved
Drinks/d	3-4	3-6	3-4

How to measure insulin sensitivity

- **In Vitro :**
 - **Adipose tissue :** Insulin-stimulated glucose uptake and lipolysis.
 - **Muscle :** Glucose disposal via GLUT₄ translocation.
 - **Liver :** Suppression of hepatic glucose production.
- **In vivo:**
 - **Hyperinsulinemic-Euglycemic Clamp :**
 - **Gold standard** for quantifying insulin sensitivity in animals and humans.
 - Measures glucose infusion rate (GIR) required to maintain euglycemia under insulin stimulation.

Metal(loids) in Tea

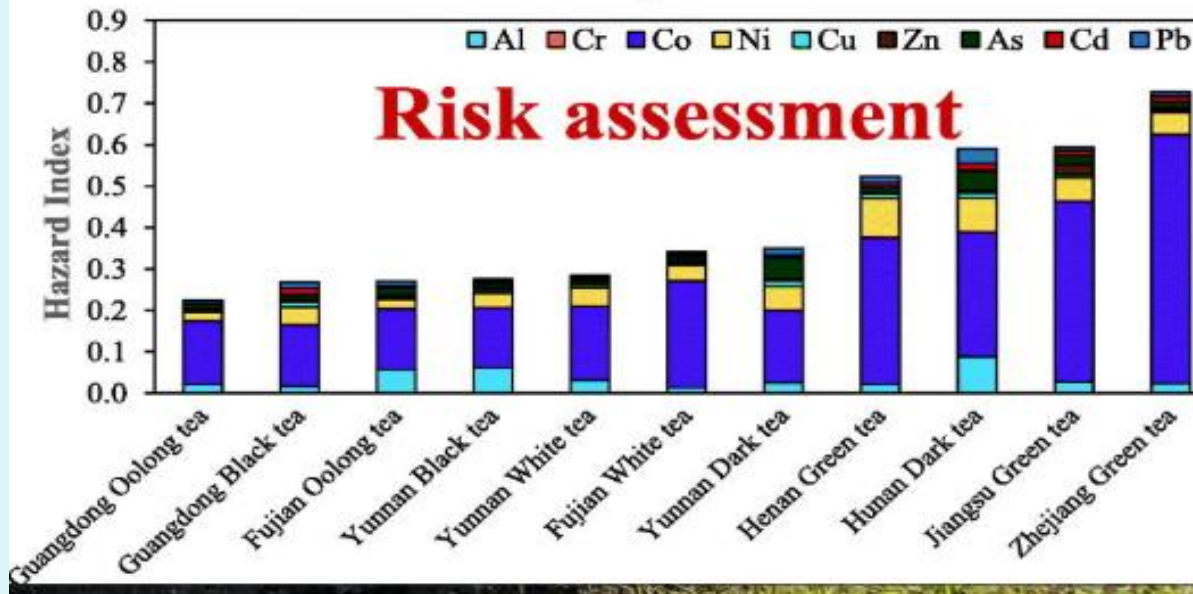
Sampling

Detection

Dark tea and green tea from certain regions pose relatively higher health risks

As and Pb in **dark tea** were markedly higher. **Hunan** dark tea should be avoid

Co Cobalt and **Al** contributed to highest hazard index values in selected tea commodities.



Metal contamination in certain Chinese tea

Hunan dark tea	As , Pb.
Longjing tea (龙井茶)	Pb , Cd, Al
西湖龙井 in Hangzhou,	Less contamination: grown in cleaner environments.
Biluochun (碧螺春)	Pb, Cd, As, Hg , in some batches
Pu-erh tea Yunnan	Pb , Cd , Al , As , in certain batches

lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg)

Industry activity is the main sources

碧螺春 (Biluochun) : Dongting Mountain area near Lake Tai in Jiangsu, not all Biluochun teas are affected.



Metals in Tea related to industrial activities

	Metal	Benefit	Toxicity (high dose)
Cr	Chromium	Supports insulin function.	Carcinogenic, respiratory issues and skin irritation.
Co	Cobalt	B ₁₂ ,	Cardiomyopathy, lung damage, and thyroid issues.
Cu	Copper	iron metabolism, connective tissue formation, antioxidant	Excess can lead to liver damage, neurological issues (Wilson's disease).
Zn	Zinc	immune function, wound healing, DNA synthesis, and enzyme activity.	High doses can cause nausea, vomiting, and copper deficiency.
Al	Aluminum	No significant health benefits.	Alzheimer, bone disorders, and anemia
As	Arsenic	No health benefits	Highly toxic; causes cancer, skin lesions, cardiovascular diseases, and neurotoxicity.
Ni	Nickel	Not essential for humans.	Allergy, respiratory, carcinogenic.
Cd	Cadmium	No benefits	Kidneys, bones, and lungs; carcinogenic and linked to osteoporosis and kidney failure.
Pb	Lead	No benefits	Neurotoxic, developmental delays, kidney

Heavy metal contamination

- Industrial pollution or volcanic soil
- Parts of China, India, and Sri Lanka may have higher levels of lead, cadmium, or arsenic.
- Toxic elements in teas tend to be predominantly released in the first infusion.
- Health risk associated with drinking tea is acceptable for the tested Chinese teas.



Heavy Metals in Green tea and Oolong tea mg/mg

	China All	China Oolong	India	USA	England	China standard
Lead (Pb)	0.5 - 2.0	0.25	0.3 - 1.8	0.2 - 1.5	0.1 - 1.0	≤ 5
Cadmium (Cd)	0.05 - 0.3	0.05	0.03 - 0.2	0.02 - 0.1	0.01 - 0.08	≤ 1
Arsenic (As)	0.1 - 0.5	0.1	0.05 - 0.4	0.03 - 0.3	0.02 - 0.2	≤ 2
Mercury (Hg)	0.01 - 0.05	0.01	0.005 - 0.04	0.003 - 0.03	0.002 - 0.02	≤ 0.3

Green tea from Japan and South Korea are compatible to USA and England. If you're buying Japanese green tea, it's worth checking the origin of the tea and any available safety certifications

Ministry of Agriculture tea heavy metals limited standards in China

- • **Lead (Pb): 5 mg/kg**
- • **Cadmium (Cd): 1 mg/kg**
- • **Arsenic (As): 2 mg/kg**
- • **Mercury (Hg): 0.3 mg/kg**
- • **Chromium (Cr): 5 mg/kg**

• Int J Environ Res Public Health 2018 Jan 13;15(1):133

Above are Regulatory testing (dry leaves) and remains more common in the literature

How the Metals are measured

Study focus	Testing method	Journal
Compliance with EU standards	Dry leaves	<i>Food Additives & Contaminants</i>
Metal leaching in infusions	Steeped liquid	<i>Environmental Science & Technology</i>
Soil-to-leaf metal transfer	Dry leaves	<i>Chemosphere</i>

Older studies (pre-2010) focused more on dry leaves

post-2015 test **both dry leaves and infusions**

Dry leaf testing is more common in tea-exporting countries (e.g., China, India)

Infusion testing is emphasized in consumer-centric markets (e.g., EU, US).

Oolong /Fujian vs Green/Hangzhou

	Oolong mg/kg	Green tea	China standard
Lead (Pb)	0.25	0.30	5.0
Cadmium (Cd)	0.05	0.07	1
Arsenic (As)	0.10	0.15	2
Mercury (Hg)	0.01	0.02	0.3



铁观音 vs 大红袍

	Anxi 铁观音	Wuyi Mountain 大红袍
Lead (Pb)	+/- varies by region	+ due to rocky soils
Cadmium (Cd)	+	+/- well-drained soils
Arsenic (As)	+ depends on soil/water	+/- due to rocky terrain
Mercury (Hg)	+/- varies by pollution	- Very low due to remote location
Aluminum (Al)	+/-	+

Both are very safe. *Journal of Agricultural and Food Chemistry*

Authors : Zhang, L., Wang, H., & Chen, X. Year : 2020



Pesticides/Chemicals Contaminations

	Green Tea	Black Tea	Oolong Tea
Pesticides			
Organochlorines	residue	residue	residue
Organophosphates	residue	residue	residue
Pyrethroids	residue	residue	residue
Glyphosate	residue (herbicide)	residue	residue
Other Chemicals			
Polycyclic Aromatic Hydrocarbons (PAHs)	During drying, smoking process	During drying, smoking process	During drying, smoking process
Fluoride	Low levels (from soil/water)	Moderate levels	Moderate levels

Chemical Contaminants in Chinese Tea

	Green	Black	Oolong
Pesticide Residues	Moderate to High	Moderate	Moderate
Heavy Metals	Moderate	Low to Moderate	Low to Moderate
Fluoride	Low to Moderate	High	Moderate
PAHs	Low	Low to Moderate	Low
Mycotoxins	Low	Low	Low
Solvent Residues	Low	Low	Low

PAHs: Polycyclic Aromatic Hydrocarbons



Adverse effects of chemicals in Chinese tea

Chemicals	Adverse Effects
Pesticides	Neurotoxicity: Cognitive decline, Parkinson's-like symptoms. Endocrine : Hormonal imbalances, reproductive issues. Carcinogenicity: Liver, breast, and prostate cancer.
Fluoride	Dental Fluorosis: Staining and pitting of teeth. Skeletal Fluorosis: Bone pain, fractures, joint stiffness. Kidney Damage: Impaired renal function.
PAHs	Carcinogenicity: Lung, skin, and bladder cancer. Cardiovascular Disease: Atherosclerosis, hypertension. Reproductive Toxicity: Reduced fertility, developmental issues.
Mycotoxin	Hepatotoxicity: Liver damage, cirrhosis. Nephrotoxicity: Kidney damage, chronic kidney disease. Carcinogenicity: Liver cancer (aflatoxins). Immune Suppression: Increased susceptibility to infections.
Solvent Residues	Hepatotoxicity: Liver damage, cirrhosis. Nephrotoxicity: Kidney damage, chronic kidney disease. Neurotoxicity: Cognitive decline, peripheral neuropathy. Carcinogenicity: Liver, kidney, and bladder cancer.

Radiation Concerns in Japanese Green Tea: 2011

Fukushima nuclear disaster

Aspect	Details
Testing & Regulation	<p>Tea-Specific Limits: limit was reduced to 100 Bq/kg (e.g., EU imports: ≤ 500 Bq/kg for Cs-137). Japan tests tea exports, EU, US independent checks.</p>
Current Status	<p>Post-2015: Most green tea below detectable levels of radiation. Cesium-134 ($T_{1/2}$: ~ 2 years) has largely decayed; cesium-137 ($T_{1/2}$: ~ 30 years) at very low levels.</p>
Affected Regions	<p>Fukushima, Ibaraki, Chiba: Some tea farms remain under monitoring, but most have resumed production.</p>
Unaffected	<p>Shizuoka, Kyoto, or Kagoshima</p>
Health Risks	<ul style="list-style-type: none"> - Low Exposure: Even slightly elevated readings (e.g., 50–200 Bq/kg) pose minimal risk. - Comparison: annual Natural background radiation = 2.4 mSv (e.g., from soil/air) often exceeds tea radiation doses.

How to reduce risk

- **Reliable source: high altitude, no industrial activity, organic certification**
- **Rinse Tea Leaves** : Rinsing tea leaves briefly before brewing to reduce residual pesticides.
- Toxic elements in teas tend to be predominantly released in the first infusion.
- **Avoiding drinking the first infusion**
- Health risk associated with drinking tea is acceptable for the tested Chinese teas.
- **Oolong tea** : Very low heavy metals and chemicals.

How to reduce the risk /continue

- **Lower temperatures:** less heavy metal leaching.
- **Green tea :** brewed at the lowest temperatures to preserve its delicate flavors and minimize metal release.
- **Oolong tea** balancing flavor and safety.
- **Black tea** staying below 95°C helps reduce the risk of heavy metal extraction.
- **Water quality :** Using filtered water can further reduce heavy metals
- **Steeping time :** Over-steeping can increase the release of heavy metals,.

Characters of teas

Tea	Brewing temp °C	Steeping time minute	Re-steeping times	Shelfer life
Oolong	85 - 96	2-4	3-5	Lightly oxidized 1-2 y Heavily roasted 2-3 y
Green	70 - 80	1-3	2-3	6-12 m
Black	90 - 96	3-5	1-2	1-2 y
Dark	96 - 100	3-5	4-6	> 10 y

Lower temperatures: less heavy metal leaching,
But less benefit, need to balance.

Caffeine in Coffee and Tea

	Serving size, oz (mL)	Caffeine, mg
Coffee, brewed	8 (240)	102 -200
Coffee, instant	8 (240)	27-173
Black tea, brewed	1 tea bag	40-70
Green tea, brewed	1 tea bag	20 - 45
Da Hong Pao	1 tea bag	30-50
Tie Guan Yin	1 tea bag	20-60
Pu-erh	8 (240)	30-70
Herbal teas	1 tea bag	0
Excedrine Migraine	caplets	130

How to make good flavor tea

- Filtered water, get rid of calcium
- Mountain fountain water, not well water
- Made from china 瓷, not paper or plastic.
- Small volume
- Tea not in tea bag
- Discard first infusion
- Follow the temperature and steeping time



Taste/small vs Health benefit/large

Tea pot set in
Minnan, China



Regular Tea Pot Set



Summary / Tea

- No randomized, long term trials available.
- Few small prospective trial showed Water is as good as coffee or tea. Hydration is important. However, no significant association was found between water intake and all-cause mortality in majority studies.
- 1-2 cups/ coffee + 2-4 cups tea/d had lower mortality risks for all-cause (HR, 0.78; 95% CI: 0.73-0.85), CVD (HR, 0.76; 95% CI: 0.64-0.91).
- Green > Oolong, black tea.
- Chose reliable sources to reduce heavy metal or chemical contamination, high altitude. Organic certification
- Adding sugar can offset the health benefit of tea