Green & Sustainable Chemistry Letters

A Narrative Review

CAMPHOR IN INDIA

Cultural use, industry and trade, socio-economic status, adulteration, price, natural versus synthetic products and route-specific health implications of burning

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ABSTRACT

Camphor ($C_{10}H_{16}O$; 2-bornanone) is a volatile bicyclic monoterpene ketone used in India in religious ritual, fragrance, topical preparations, food and industry. It can be recovered from Cinnamomum camphora as optically active (+)-camphor or made from turpentine-derived α-pinene as the racemate. This narrative review describes the chemistry, trade, socio-economic and price analyses and another two things. First, it compares natural camphor, synthetic camphor and commonly marketed products (ritual tablets, 'smokeless' tablets, Bhimseni or crystal camphor, 'edible' camphor, camphor oil and topical products). Origin changes the enantiomeric composition and impurity profile, but the formulation of the product is likely to matter more for combustion emissions and no study located compares the toxicology of the forms directly. Second, the health section is built around route of exposure, because direct exposure (skin, eye and unburned vapour), ingestion and inhalation of combustion emissions differ in agent, dose and evidence. Ingestion, especially by children, is the best-documented danger and can cause seizures within minutes to hours. Evidence on combustion emissions comes only from incense studies, which show that ritual burning can raise particulate matter far above air-quality benchmarks but are not camphor-specific. Fullerenes (C_{60} and related species) were isolated from camphor soot in laboratory work in 1994, and camphor is a feedstock for carbon nanotubes under furnace conditions. Fullerenic carbon is, however, a general feature of hydrocarbon flame soot, and its amount, airborne form and health significance in household camphor burning have not been measured. Official tariff-line data for FY 2024–25 show net exports of synthetic camphor (₹94 crore exported versus ₹34 crore imported), which does not support heavy import dependence. A convenience sample of 49 marketplace listings gave a median of ₹650/kg for ritual tablets, so 30 g a month costs about ₹20. Visible soot is not a specific test for adulteration. Evidence on production volumes, adulteration prevalence, labour conditions, emission profiles and exposure remains thin and the review proposes a research agenda.

Key words: Camphor; kapoor; India; natural camphor; synthetic camphor; socio-economic status; adulteration; soot; fullerenes; combustion emissions; indoor air pollution; particulate matter; ingestion; toxicology; affordability.

1. Scope and review approach

This is a narrative review, not a systematic review or meta-analysis. Sources were chosen for direct relevance and traceability: peer-reviewed chemistry, toxicology and air-quality papers; official chemical-safety resources (ICSC, NIOSH, INCHEM); the Bureau of Indian Standards (BIS); Indian government household-expenditure statistics; tariff-line trade data; and marketplace listings for illustrative prices. In this revision every reference in the earlier draft was checked against a publisher, database or official page.

Two limits apply throughout. First, trade figures come from secondary websites that republish official tariff-line data, so they should be confirmed in the Ministry of Commerce TradeStat database before being used in a formal publication. Second, marketplace listings are advertisements, not transactions; they are shown to indicate order of magnitude only.

This review adds a comparison of natural, synthetic and marketed camphor (Section 4) and rebuilds the health section by route of exposure (Section 10). The new material draws on pharmacopoeial monographs, poison-information and case-report literature, incense and indoor-air studies, and the materials-science literature on camphor-derived carbon. Product-category descriptions (Table 4) rely

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partly on trade and newspaper sources, which are labelled as secondary. No study of the emissions from burning camphor itself, and no study comparing the toxicity of natural with synthetic camphor, was found; statements on those points are therefore reasoned from adjacent evidence and marked as inference.

2. Chemistry and forms of camphor

Camphor is a bicyclic monoterpenoid ketone, a white crystalline solid with a penetrating odour and enough vapour pressure to sublime at room temperature (Table 1). Natural camphor is associated with *Cinnamomum camphora* (wood-derived oil), whereas commercial synthetic camphor is commonly made from turpentine-derived α-pinene [1–3,9]. Synthetic routes usually give racemic camphor, while botanical sources are optically active (dextrorotatory in the natural form) [9]. Reviews of camphor chemistry and use as a chiral building block are given in references 2 and 3; reference 1 is a general terpene review and supports only background context.

Labels such as ‘natural’, ‘puja’, ‘Bhimseni’, ‘edible’, ‘medicinal’ and ‘100% pure’ are not interchangeable quality grades. ‘Bhimseni’ is a trade name whose chemical meaning varies between sellers, so identity and intended-use grade should be established analytically. A product suitable for ritual burning is not automatically suitable for ingestion, food use or medicine. The differences between these labels, and what they imply for toxicity, are discussed in Section 4.

Table 1. Physicochemical and safety data for camphor (verified from official sources).

Property	Value	Source
Formula; molar mass	$C_{10}H_{16}O$; 152.2–152.3 g/mol	[10]
Melting point; boiling point	about 174–177 °C; about 204 °C	[10]
Vapour pressure (room temp.)	0.2 mmHg (sublimes)	[10]
Flash point; explosive limits	about 65 °C (150 °F); 0.6–3.5% in air	[10]
Occupational limits	NIOSH REL: TWA 2 mg/m³ OSHA PEL: TWA 2 mg/m³	[10]
Immediately dangerous to life or health	200 mg/m³	[10,11]
Target organs / acute effects	Eyes, skin, respiratory tract, central nervous system; nausea, headache, dizziness, convulsions	[8,10]
Historical lethal-dose estimates (pure camphor, ingestion)	Adults about 4 g; children about 1 g	[9]
Optical forms	(+) and (−) enantiomers and racemate exist	[8,9]

3. Production, industry and trade

Two broad routes supply the market. Botanical recovery uses steam distillation of camphor-tree material followed by separation and purification. Chemical synthesis converts α-pinene through camphene and isobornyl intermediates to borneol or isoborneol and then oxidises or dehydrogenates this to camphor [1–3]. Camphor supports several linked value chains (Figure 1): Ritual tablets and cubes; pharmaceutical and topical products; fragrance and flavour ingredients; household products; and specialty chemicals. Indian manufacturers named in a market-profile document include Oriental

Aromatics, Camphor & Allied Products and Saptagir Camphor [13,14], so India has a domestic synthetic-camphor industry rather than relying wholly on imports.

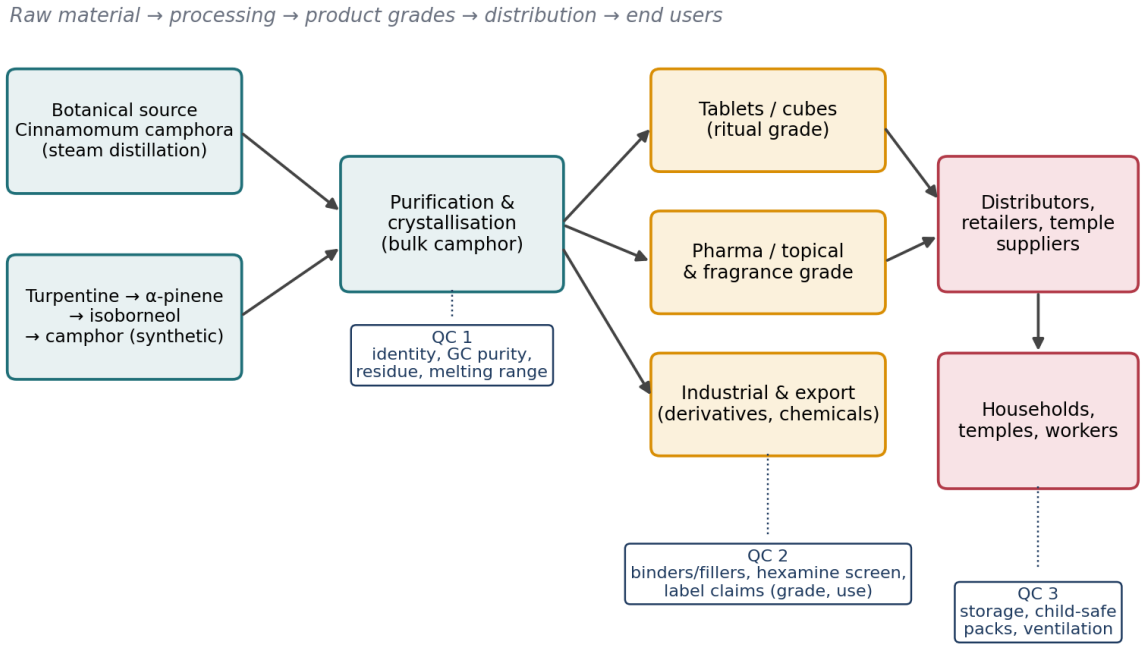

Figure 1. Simplified camphor supply chain with three quality-control (QC) points. Schematic, not a measured material-flow analysis.

3.1 What the trade data show

The earlier draft stated that India is a major importer and that imports are a large share of supply, citing a 2022–23 Oriental Aromatics annual report. That file could not be accessed, and the 2023–24 and 2024–25 reports could be located but not extracted in readable form, so the claim is **not verified** and is withdrawn. A second pitfall also needs flagging: one trade website reports about US$1.1 billion of ‘camphor’ imports in 2024, but this figure is for the whole of HS heading 2914 (ketones and quinones), not camphor alone [15]. Camphor-specific tariff lines are far smaller (Table 2, Figure 2).

Table 2. India’s trade in camphor tariff lines, FY 2024–25 (₹ crore). Source: TradeStat data as republished by BUSY [14]; confirm in TradeStat before formal use.

Tariff line (HSN)	Exports	Imports	Comment
29142922 Synthetic camphor	94.48	33.52	Net exporter; exports were ₹163.67 crore in FY 2018–19, falling about 8.8% a year; imports −21.7% in FY 2024–25
29142921 Camphor sub-line	1.34	34.72	Net importer; description of this line not confirmed in the source
29142950 Camphor derivatives	336.83	0.24	Strongly export-oriented
33012941 Camphor oil	1.79	1.00	Very small

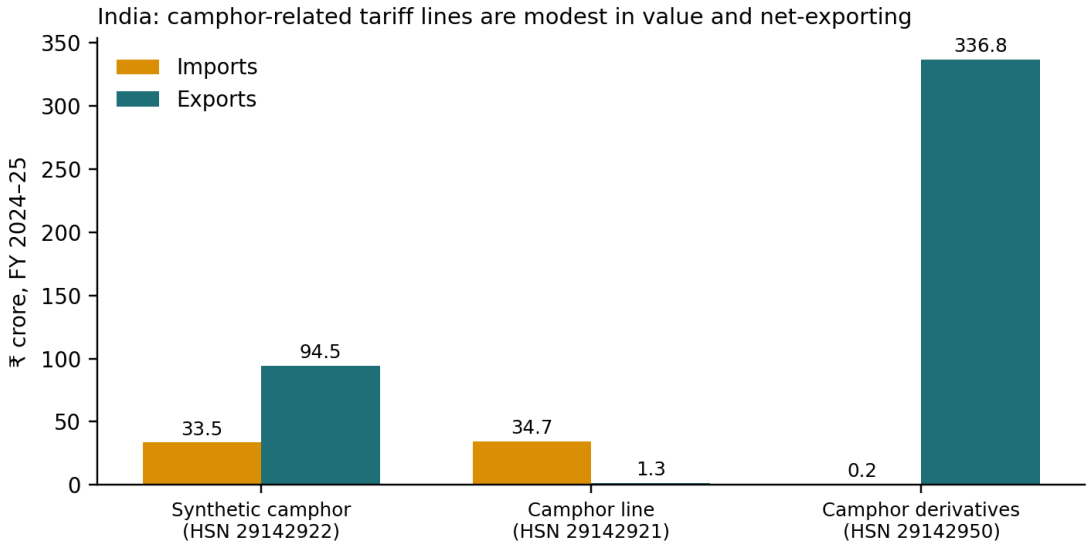

Figure 2. Exports and imports for camphor-related tariff lines, FY 2024–25 (₹ crore). Data from Table 2.

Taken together, the two camphor lines record about ₹68 crore of imports against about ₹96 crore of exports. A discrepancy with company statements about import dependence therefore remains unresolved. Plausible explanations are differences in tariff classification (camphor imported under other headings or as derivatives), grade-specific dependence (for example, natural or specialty grades) and differences between value and volume. Volume data by grade are not publicly available in the sources reviewed.

4. Natural, synthetic and marketed camphor: A comparative discussion

Three different things are sold in India as ‘camphor’ or ‘kapoor’: the molecule recovered from plants, the molecule made from turpentine, and a formulated product sold under a brand or trade name. They overlap but are not equivalent. This section separates them because the toxicology in Section 10 depends on which of them is being handled, swallowed or burned.

4.1 Natural camphor

Natural camphor is the dextrorotatory (1R)-enantiomer recovered by steam distillation of *Cinnamomum camphora* wood, chips or leaf and then crystallised or sublimed [2,9]. It is optically active: the pharmacopoeial monograph for natural camphor specifies a specific rotation of about +40 to +43°, a melting point of 175–179 °C and a gas-chromatographic limit for borneol of 2% [31]. Oils from the tree vary with chemotype; constituents listed in the Ayurvedic literature for the leaf include cineole, linalool, eugenol, limonene, safrole and pinenes in addition to camphor [35]. How much of this reaches crystalline retail product depends on refining and is not documented for Indian products. Classical Indian texts distinguish a ‘pakva’ (processed) camphor, linked to *C. camphora*, from an ‘apakva’ (crude, natural) camphor linked to *Dryobalanops aromatica* [33]. Borneo or Barus camphor from *D. aromatica* is generally described as borneol-rich rather than a ketone; this was not verified in this revision, but it is a reason to test any product sold under the trade name Bhimseni. Natural material is expected to cost more than synthetic, but the marketplace sample could not separate the two, and price does not establish origin (Section 7).

4.2 Synthetic camphor

Synthetic camphor is made from α-pinene in turpentine by acid-catalysed rearrangement to camphene, esterification to isobornyl acetate, hydrolysis to isoborneol and oxidation to camphor [2,9]. The product is racemic and shows essentially no net optical rotation; a supplier specification for BP-grade racemic camphor gives −0.15 to +0.15° [32]. Impurities reflect the route: camphene, borneol and isoborneol, isobornyl esters, other terpene hydrocarbons and trace reagents. The same supplier sheet, quoting the British Pharmacopoeia, describes a halogen limit of 100 ppm and limits of about 2% for any single related substance [32]. These are pharmacopoeial controls, and there is no evidence that ritual-grade

tablets are made to them. India has domestic producers and is a net exporter on the main synthetic tariff line (Section 3.1); no public volume split between natural and synthetic camphor in India was found.

4.3 Commonly marketed products

Indian retail products are better described by use category than by origin (Table 4). The word ‘camphor’ covers ritual tablets, crystals sold as Bhimseni, ‘edible’ camphor used in South Indian sweets such as pongal [34], oils, topical products and blends. The marketplace price sample (Section 7) did not record origin, and ‘natural’, ‘pure’, ‘smokeless’ and ‘edible’ are marketing terms rather than defined grades (Section 2).

Table 3. Natural, synthetic and marketed camphor compared. ‘None located’ means no study was found in the sources reviewed.

Feature	Natural camphor	Synthetic camphor	Marketed products
Starting material	*C. camphora* wood or leaf (other botanical sources exist)	Turpentine-derived α-pinene	Either source or a blend; declaration practice not surveyed
Enantiomeric form	(1R)-(+), optically active	Racemic (±); rotation about 0°	Depends on source; testable by rotation or chiral GC
Co-constituents and impurities	Borneol and chemotype-dependent terpenoids [31,35]	Camphene, isoborneol or borneol, isobornyl esters, trace reagents [32]	Possible binders, fillers, fragrance, coatings; largely undocumented
Specification benchmark	Natural camphor monograph: rotation +40 to +43°; melting point 175–179 °C; borneol ≤2% [31]	Racemic camphor: rotation −0.15 to +0.15°; halogens ≤100 ppm (supplier quoting BP) [32]	BIS IS 3584:2007 exists; retail compliance not studied [12]
Typical Indian use	Ayurvedic, ‘edible’, premium ritual	Bulk ritual, topical, industrial	All of these
Systemic toxicity of the molecule	Poisoning guidance treats camphor as one substance [4,9]	Same	Depends on camphor content and additives
Combustion emissions	Same fuel molecule; trace terpenoids may differ (not studied)	Same fuel molecule; route impurities may differ (not studied)	Additives and burning conditions probably dominate (inference)
Direct comparison of toxicity	None located	None located	None located

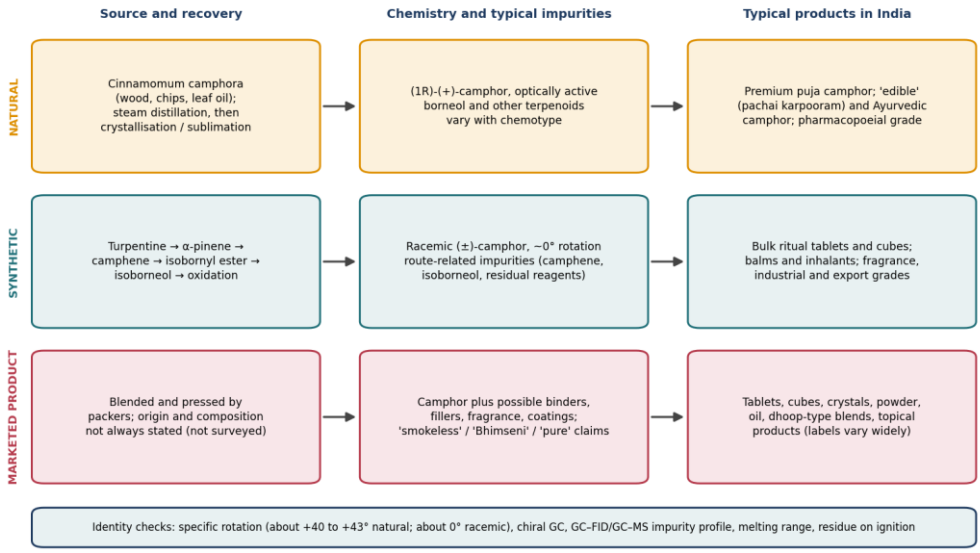

Figure 3. Natural, synthetic and marketed camphor: source, chemistry and typical products. Schematic synthesis for this review, not a measured material-flow analysis.

Table 4. Commonly marketed camphor product categories in India and the exposure route of greatest concern. Origin entries marked (inference) are not label data.

Category	Form and use	Likely origin	Main identity or quality question	Route of greatest concern
Ritual tablets and cubes	Pressed tablets burned in aarti and household worship; 41 of 49 sampled listings	Probably synthetic in most cases (inference); declaration practice not surveyed	Camphor content; binders or fillers; residue after burning	Combustion emissions; accidental ingestion by children
'Smokeless' tablets	Marketed as producing little smoke; 4 sampled listings	Not stated	Claim untested; formulation unknown	Combustion emissions (claim unverified)
Bhimseni or crystal camphor	Crystals or lumps for ritual and traditional medicine; 3 sampled listings at ₹1,050/kg	Variable: natural, borneol-rich or purified synthetic	Ketone or alcohol; enantiomeric composition	Ingestion if used medicinally; combustion
'Edible' camphor (pachai karpooram)	Pinch quantities in sweets, drinks and paan [34]	Described as natural, *C. camphora*, in secondary sources [33,34]	Whether any food specification is met; purity	Ingestion; narrow margin between flavouring and toxic amounts
Camphor oil	Liquid for lamps, massage and ritual	Fractions of *C. camphora* oil or synthetic blends	Composition, including safrole in some chemotypes [35]	Skin contact, ingestion, burning
Balms, liniments and inhalants	Medicinal or cosmetic products with a stated camphor percentage	Usually synthetic (inference)	Declared concentration; labelling [5]	Direct exposure; ingestion by children
Look-alike products	Other volatile chemicals sold in similar shapes, such as mothballs	Not camphor	Confusion or substitution: no Indian data located	Different toxicology; verify identity

4.4 What the comparison implies

Three conclusions follow. First, for acute systemic toxicity the molecule matters more than its origin: natural and synthetic camphor are the same ketone, and clinical guidance does not distinguish them [4,9]. That is an absence of evidence rather than a demonstration of equivalence, because no study located compares (+)-camphor with racemic camphor in humans. Claims that natural camphor is safe to eat, or that synthetic camphor is uniquely hazardous, are therefore unsupported. Second, origin plausibly changes minor constituents and so irritancy, odour and trace combustion by-products, but this is untested. Third, in the products actually sold, formulation is likely to be the largest source of variation in emissions, because binders, fillers, fragrances and coatings differ between brands whatever the origin of the camphor (inference). Any statement about a particular product should therefore rest on tests of that product.

5. Uses

In households and temples camphor is burned during puja and aarti. It is also a fragrance ingredient, a moth repellent and an ingredient in regulated topical preparations where concentration matters [4,5]. Industrial users need tighter identity, purity and documentation than ritual users. Camphor is combustible; bulk storage and processing need ventilation, ignition control and occupational hygiene [10]. These uses expose people by different routes (skin and vapour contact, ingestion and inhalation of smoke), and the risks differ by route (Section 10).

6. Socio-economic status of camphor in India

This section is new. It combines the evidence located in this revision with clearly labelled inference. Camphor-specific socio-economic research is almost absent, so several conclusions rely on analogies (notably the incense-stick sector) and on price and expenditure arithmetic. Table 5 states how strong the evidence is for each dimension.

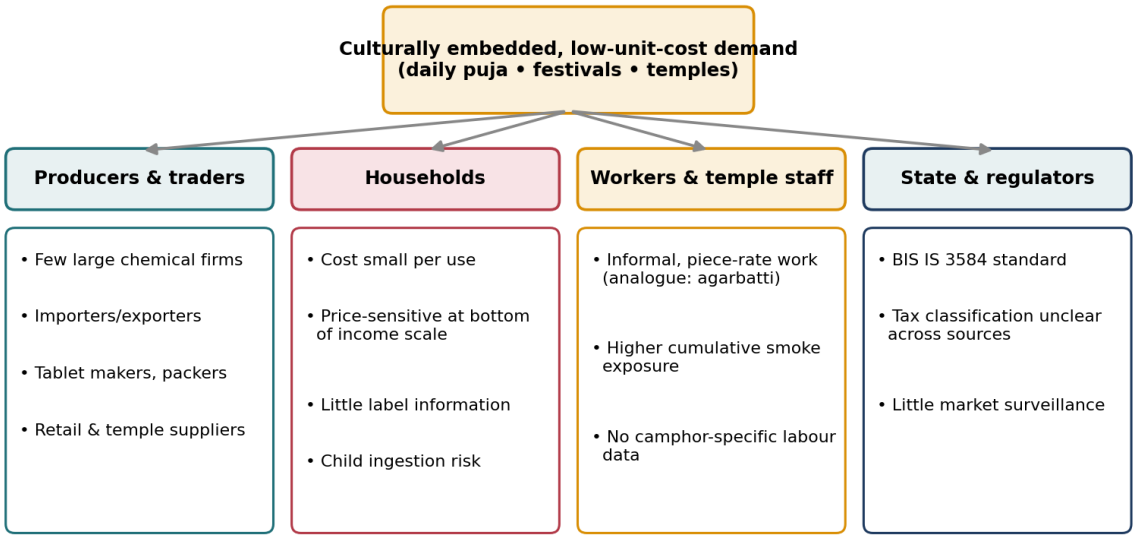

Figure 4. Socio-economic framework: one culturally embedded demand source and the four groups affected. Conceptual diagram synthesised for this review.

6.1 Demand: A low-cost, culturally embedded necessity

Camphor use cuts across income groups because it is tied to daily and festival worship rather than to discretionary consumption. This suggests demand that is relatively insensitive to price, although no Indian price-elasticity study for camphor was found. Because the unit cost per ritual is tiny, the household budget effect is small. At the sample median of ₹650/kg (Section 7), use of 10, 30 or 100 g a month costs about ₹6.5, ₹19.5 or ₹65. Measured against the 2023–24 Household Consumption Expenditure Survey (average monthly per capita spending of ₹4,122 in rural and ₹6,996 in urban India, and ₹1,677 for the poorest 5% of rural people) [16], this is 0.1–1.6% of average spending and up to about 3.9% for heavy use in the poorest group (Figure 6). Household size is not accounted for, so this compares a household's cost with one person's spending and overstates the burden; it is an upper-bound illustration.

The practical implication is that camphor is affordable for nearly everyone, so quality, not price, is likely the main equity concern. A buyer at the low end of the price range has little ability to check purity, and a seller has little incentive to document it.

6.2 Supply: Concentrated manufacture, fragmented distribution

Manufacture appears concentrated in a few chemical companies, while distribution, tablet pressing, packing and retail are dispersed across small enterprises and temple suppliers. Company reporting from Oriental Aromatics indicates that the 'spiritual' segment is growing and that pricing is under pressure from higher global supply [13]; this is company disclosure, not independent market data. Trade data (Section 3.1) show India exporting more synthetic camphor than it imports, which links domestic livelihoods to global (particularly Chinese) supply conditions through price competition. The distribution of margins between manufacturer, wholesaler and retailer was not found in public sources and should be a priority for field study.

6.3 Livelihoods and labour

No camphor-specific estimate of employment was found. The closest well-documented analogue is the incense-stick (agarbatti) sector, which shares ritual demand and small-enterprise structure. Industry sources put its workforce at about four lakh people (2021) and, in a different statement, above two million (2019), with around 80% women, many working at home and paid by piece rate [17–19]. A 2019 report found rolling pay below the statutory minimum wage (the notified rate was ₹43–49 per 1,000 sticks) [19]. Figures differ by a factor of five, which signals how poorly the sector is measured. By analogy only, camphor tablet pressing and packing in small units may involve similar informal and

low-wage work, with occupational exposure to camphor dust and vapour; this requires verification. Temple staff and priests, who may breathe ritual smoke for hours daily, are a second plausible occupational group, supported indirectly by the Kanpur temple measurements [7].

6.4 Health, exposure and inequality

Exposure to camphor smoke and vapour depends on the room, not only the product. Small, poorly ventilated homes, burning in shrine corners, and co-exposure to cooking smoke raise exposure; these are more common in lower-income households (inference; no camphor-specific exposure-by-income study was found). Children are a particular concern for ingestion. An Indian Pediatrics case report describes a 3-year-old in Bangalore who ate about two ritual camphor cubes, mistaking them for sugar cubes, and had seizures within about 30 minutes before recovering fully [5]. The authors note that, unlike the US where products are capped at 11% camphor, concentration is often not stated on products in India [5]. Because ritual camphor is sold loose, in unmarked pouches or in tablet jars without child-resistant closures, the burden of accidental poisoning plausibly falls on households with fewer resources for safe storage and rapid care (inference).

6.5 Tax, regulation and enforcement

Secondary sources disagree on the Goods and Services Tax (GST) rate for camphor: depending on HSN classification and date, they variously report 5%, 12% and 18%, and several describe changes after 22 September 2025. The rate therefore cannot be stated reliably here; readers should check CBIC Notification 9/2025–Central Tax (Rate) for the specific tariff line. The broader point is that classification (pure camphor, burning preparation, medicinal use) affects both tax and regulation, and ambiguity gives room for misdeclaration. The BIS specification IS 3584:2007 exists and was last reviewed in 2022 [12], but no study of how often retail products comply was found.

Table 5. Socio-economic dimensions, evidence located and gaps.

Dimension	Evidence located	Strength	Main gap
Demand and spending	Median ₹650/kg for tablets; 10–100 g/month costs ₹6.5–65; HCES per-capita spending [16]	Moderate (arithmetic on real data)	Actual household use and spending; price elasticity
Industry structure	Domestic synthetic producers exist; company reports note growth and price pressure [13,14]	Weak–moderate	Capacity, output, market shares; independent data
Trade	Net export on synthetic line; small camphor imports [14]	Moderate (secondary source)	Volumes by grade; confirm in TradeStat
Employment	None camphor-specific; incense analogue 4 lakh to >2 million, ~80% women [17–19]	Weak (analogy)	Camphor tablet and packing workforce, wages
Health inequity	Child ingestion case in Bangalore [5]; temple PM data [7]; incense chamber study [6]	Weak–moderate	Exposure by income, housing and occupation
Tax and regulation	BIS IS 3584:2007 reviewed 2022 [12]; GST rate sources conflict	Weak	Compliance rates; correct GST classification

7. Price and affordability

Prices vary with claimed origin, purity, form, brand, pack size, location and intended use. Across 49 single-valued listings (₹ per kg) seen on ExportersIndia, IndiaMART and TradeIndia between 26 and 27 October 2026 [21], the median was ₹650/kg with an interquartile range of ₹580–850. Ritual and worship tablets (n = 41) had a median of ₹650/kg and a range of ₹245–2,200; ‘smokeless’ tablets (n = 4) a median of ₹595; Bhimseni- or crystal-labelled products (n = 3) were each ₹1,050; and one powder listing was ₹505 (Table 6, Figure 5). Per-piece and implausible entries (for example ₹34.54/kg) were

excluded. The earlier draft's ranges (₹150–1,000 and ₹900–3,600/kg) could not be reproduced and have been replaced.

Table 6. Marketplace price sample, October 2026 (₹/kg). Convenience sample; not a price index.

Category	n	Median	Interquartile range	Minimum	Maximum
General / worship tablets	41	650	590–850	245	2,200
Smokeless-labelled tablets	4	595	513–670	400	760
Bhimseni / crystal	3	1,050	1,050–1,050	1,050	1,050
Powder	1	505	–	505	505
All listings	49	650	580–850	245	2,200

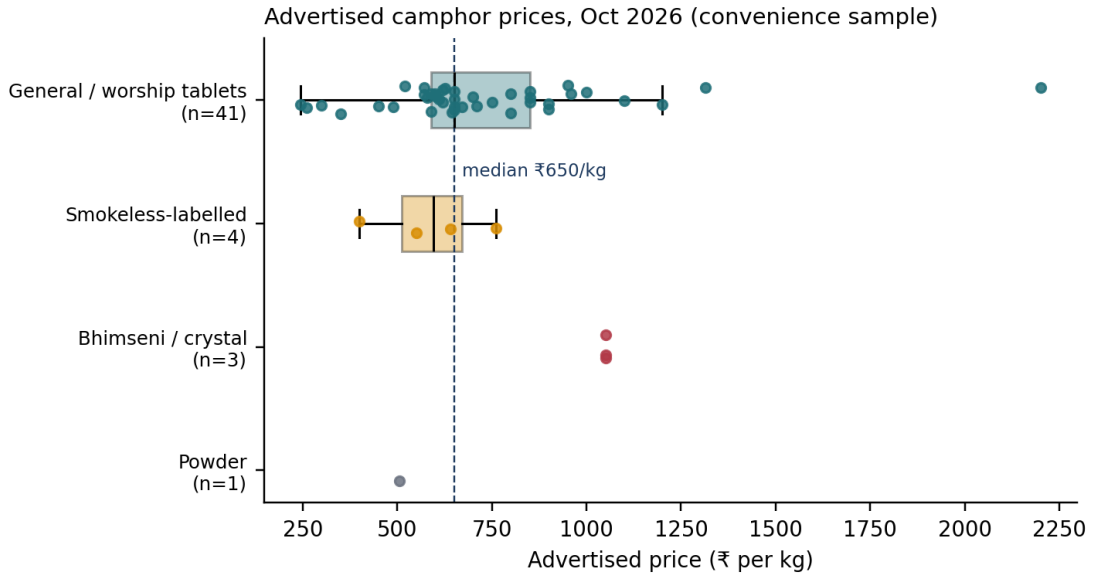

Figure 5. Distribution of advertised prices by category. Points are individual listings; boxes show the interquartile range for the two categories with enough observations.

Table 7. Illustrative monthly cost of camphor at ₹650/kg and its share of one person's average monthly spending (HCES 2023–24 [16]).

Use per month	Cost (₹)	Rural, poorest 5% (₹1,677)	Rural average (₹4,122)	Urban average (₹6,996)
10 g	6.5	0.4%	0.2%	0.1%
30 g	19.5	1.2%	0.5%	0.3%
100 g	65.0	3.9%	1.6%	0.9%

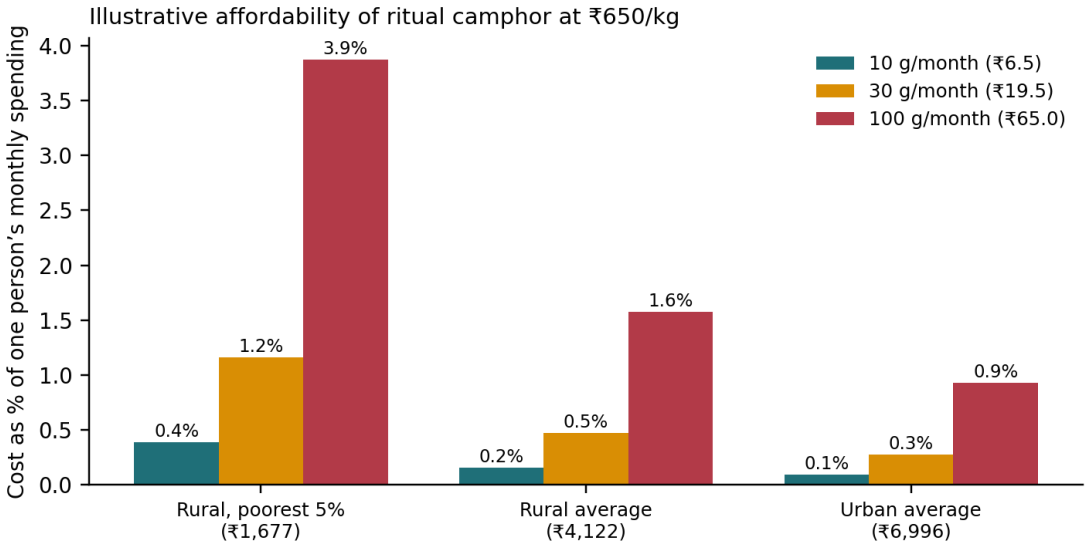

Figure 6. Camphor cost as a share of monthly spending per person. Household size is ignored, so the shares are upper-bound illustrations.

One cannot infer purity from price. A low price is a reason to check traceability, not proof of adulteration. A reproducible price study would sample the same grade and pack size across states and seasons, record tax and freight, verify sellers and test representative batches by GC–MS or GC–FID.

8. Adulteration, substitution and quality assurance

Potential quality problems include substitution with cheaper volatile or non-volatile materials, undeclared binders or fillers in compressed products, contamination during manufacture or packing, and misleading use of 'natural' or 'pure'. BIS IS 3584:2007 (Camphor—Specification, second revision) exists, was reviewed in 2022 and has one amendment [12]. The publicly available preview lists referenced methods for sampling, optical rotation, ethanol miscibility, residue on evaporation, melting range, gas chromatography and olfactory assessment. The earlier statement that the standard includes a hexamine test could **not** be verified from the preview and should be checked against the full standard. No robust national survey of adulteration prevalence was found.

Recommended analysis: (1). packaging and lot documentation as preliminary checks only; (2). melting range and residue as screening tools; (3). GC–FID or GC–MS for identity, volatile profile and organic impurities; (4). FTIR, Raman or thermal analysis where appropriate; (5). validated methods for specific suspected additives; and (6). confirmation in an accredited laboratory. White colour, strong odour, a clean flame or no residue is not proof of purity.

Table 8. Practical interpretation of quality signals. None alone proves adulteration.

Observation	What it may mean	What is needed to conclude
Black soot on vessel or ceiling	Incomplete combustion; wick or fuel effects; non-volatile ingredients	Controlled burn comparison plus chemical analysis of product and residue
Unusually low price or vague label	Possible grade or supply-chain concern; not proof	Invoice, manufacturer and lot traceability, certificate of analysis
High ash or residue after burning	Mineral filler, binder, contamination or combustion conditions	Residue mass and elemental or chemical analysis
Unusual odour, colour or melting behaviour	Impurity, formulation difference or storage contamination	Validated identity and purity methods (GC, spectroscopy)
Label says 'natural' or 'Bhimseni'	Marketing or vernacular term used inconsistently	Botanical and chemical identity; transparent grade specification

9. What does soot from burning camphor mean?

Camphor is combustible. With enough oxygen, combustion tends toward gaseous products; when burning is incomplete, carbonaceous particles and irritating gases form. Soot also depends on flame temperature, airflow, the surface and any wick or oil, and the composition of a tablet or cone. The presence and identity of binders must be established rather than assumed. No controlled evidence located validates visible soot as a stand-alone test for adulterated camphor. A soot-heavy product warrants caution, particularly with a vague label or heavy residue, but appearance cannot separate pure camphor burning poorly from an adulterated product burning differently. A meaningful comparison would standardise tablet mass, burner, wick, airflow, duration and room volume, measure PM2.5/PM10 and volatile organic compounds, and analyse the unburned tablet and residue. Soot is also a carrier of carbon nanostructures: laboratory work has isolated fullerenes from camphor soot [22,23], but this does not make visible soot a marker of fullerene content or of adulteration (Section 10.4).

10. Health implications by route of exposure

Earlier drafts, and much popular discussion, treat ‘camphor exposure’ as a single hazard. The three main routes differ in agent, dose, speed of harm and quality of evidence (Table 9, Figure 7). Direct exposure involves camphor itself. Ingestion involves camphor plus any additives swallowed. Inhalation of combustion emissions involves a mixture of combustion products whose composition depends on how a product burns, not only on the camphor in it. The routes cannot be added together or read across: a low-smoke burn says nothing about ingestion risk, and ingestion toxicity does not predict harm from smoke.

Table 9. Route-specific toxicology of camphor in Indian use. Evidence strength refers to evidence for that route, not to overall safety.

Route	Typical scenario	Principal agent	Main hazards	Does the form of camphor matter?	Evidence
Direct exposure	Handling tablets; topical balms; loose storage; dust and vapour at pressing units; vapour in small closed rooms	Camphor solid, dust and vapour	Eye, skin and airway irritation; absorption through skin and airways [8,10]; workplace TWA 2 mg/m³, not a household limit [10]	Molecule similar in natural and synthetic; concentration and carrier matter most	Strong for hazard; weak for Indian exposure
Ingestion	Child eats tablets mistaken for sweets [5]; oral use as ‘edible’ camphor or home remedy	Camphor plus any additives	Nausea, then seizures and CNS depression; historical lethal estimates about 4 g (adult) and 1 g (child) [9]	Origin not shown to matter; dose per body weight does; additives unknown	Strong: guideline [4], monograph [9], Indian case [5]
Inhalation of combustion emissions	Aarti or diya burning; shrine rooms; temples; prolonged burning in closed rooms	Soot and PM2.5, CO, VOCs, carbonyls, PAHs; trace fullerenic carbon	Airway irritation; PM above benchmarks inferred from incense [6,7,30]; chronic effects unknown	Formulation, burning conditions and ventilation matter; origin untested	Weak: incense proxy only; no camphor emission data

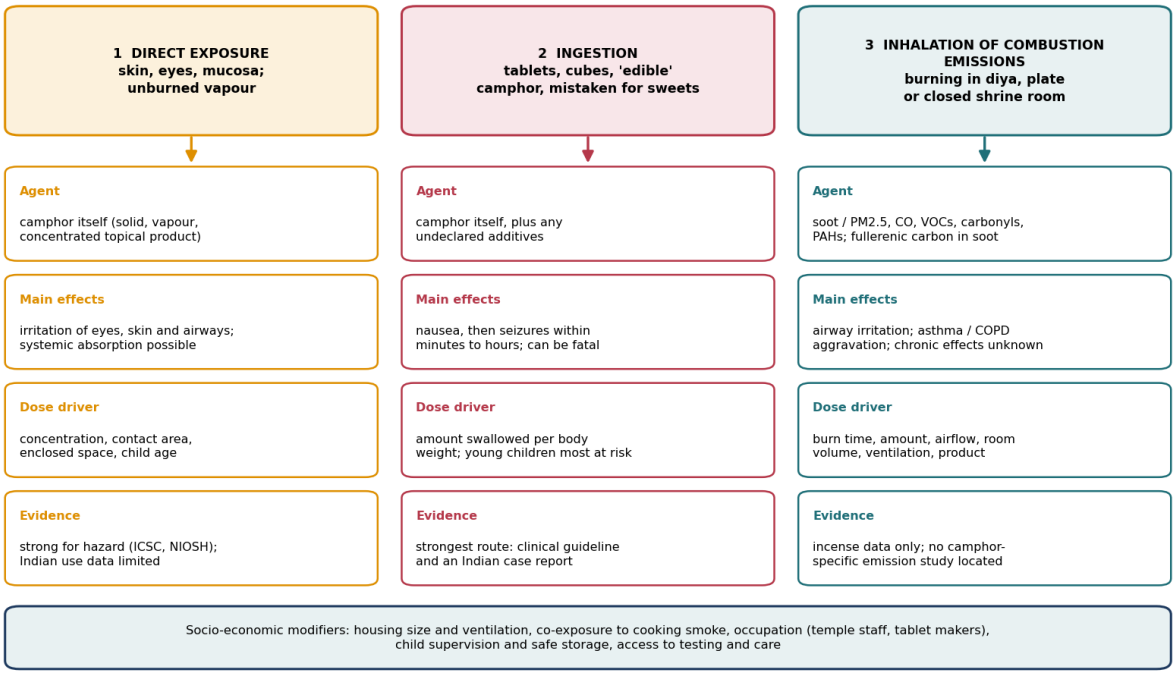

Figure 7. Three routes of exposure to camphor, redrawn from the earlier single pathway. Conceptual; not a measured emission profile for any Indian product.

10.1 Direct exposure (skin, eyes, mucosa and unburned vapour)

Direct contact involves camphor as a solid, dust or vapour rather than smoke. ICSC 1021 (dated July 2003) and the NIOSH Pocket Guide list irritation of the eyes, skin and respiratory tract and effects on the central nervous system, with absorption by inhalation, through the skin and by ingestion [8,10]. NIOSH and OSHA each list a time-weighted average of 2 mg/m³, and NIOSH gives 200 mg/m³ as the immediately dangerous level [10,11]. These are workplace limits; they are not household safety thresholds and cannot be used to judge ritual exposure without measurement. Camphor sublimes at room temperature (Table 1), so loosely stored tablets and tablet-pressing units release vapour without any burning. Topical products carry their own risk because the dose depends on the concentration; the Indian case report notes that, unlike the 11% cap applied in the United States, concentration is often not stated on products in India [5].

10.2 Ingestion

Ingestion is the most dangerous route and the best documented. Seizures can start within minutes, and an evidence-based guideline reviews out-of-hospital management [4]. Historical lethal-dose estimates for pure camphor are about 4 g for adults and about 1 g for children [9]; such figures are uncertain and do not define a safe dose. In an Indian Pediatrics case report a 3-year-old in Bangalore who ate about two ritual camphor cubes, mistaking them for sugar cubes, had seizures within about 30 minutes and recovered fully [5].

The product comparison (Section 4) adds three points: (i). Origin: No study located shows that natural camphor is less toxic when swallowed than synthetic camphor, so ‘natural’ or ‘edible’ on a label should not be read as a safety claim. (ii). Intended use: Culinary ‘edible’ camphor is used in pinch quantities [34], and the margin between a flavouring and a toxic amount is narrow and hard to judge by eye. Some commercial Ayurvedic information pages advise daily oral use [36]; this review located no clinical evidence supporting such use, and oral use of any camphor product should follow qualified medical advice. (iii). Product: Ritual tablets may contain binders or other additives of unknown identity, so an ingested tablet cannot be assumed to equal pure camphor. Ingestion by a child is an emergency that needs urgent medical help.

10.3 Inhalation of combustion emissions

Burning is different from vapour contact because it creates new substances. Camphor melts and sublimes, and its vapour burns with a luminous flame. With enough oxygen the products are carbon dioxide and water, but real flames burn incompletely, and camphor soot is easy to collect, which is how the fullerene studies in Section 10.4 obtained it [22,23]. Incomplete combustion generally yields particulate soot (black and organic carbon), carbon monoxide, volatile organic compounds, carbonyls such as formaldehyde and polycyclic aromatic hydrocarbons (inference from combustion chemistry; no camphor-specific speciation was located).

Fine particles can reach deep into the lungs. Direct camphor-tablet emission data were not found, so adjacent incense evidence is used and should not be attributed to camphor. A study of incense burning inside temples in Kanpur reported PM10 as high as 2,184 µg/m³, with more than 99% of particles by count in the PM2.5 range [7]. An experimental-house study reported indoor PM2.5 up to 197 µg/m³ and spread to other rooms [6]. For context, India's 24-hour ambient standards are 100 µg/m³ (PM10) and 60 µg/m³ (PM2.5), and the 2021 WHO guideline values are 45 and 15 µg/m³ [20]. Figure 8 compares them, but the reported values are maxima and the benchmarks are 24-hour averages, so the comparison indicates scale only.

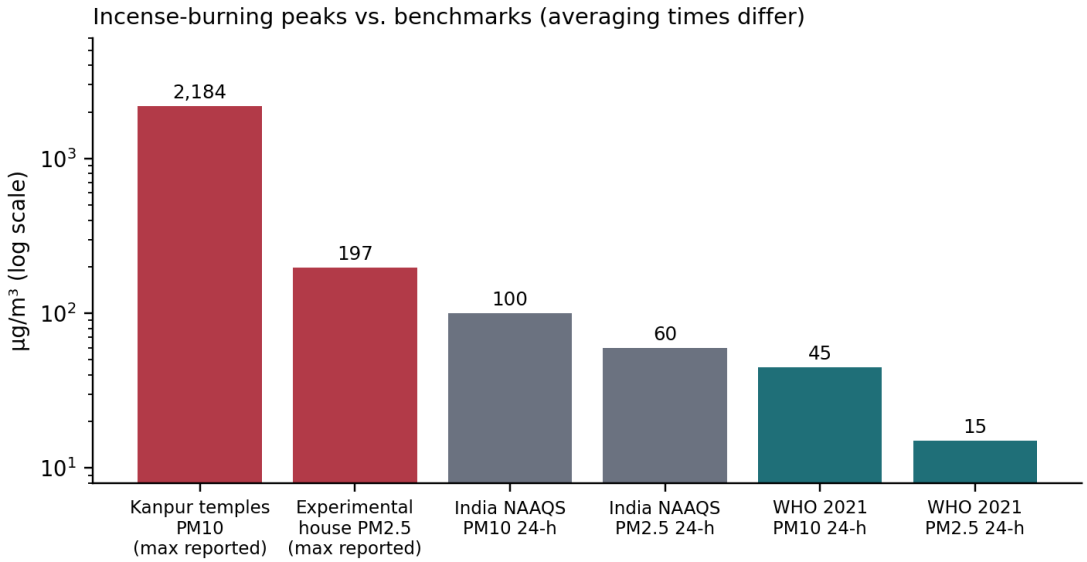

Figure 8. Reported incense-burning maxima versus benchmarks (log scale). Benchmark values from CPCB and WHO guidance [20].

A chamber study of ten incense types found that burning raised particulate matter, carbon monoxide, nitrogen oxides and volatile organic compounds, and that particulate levels exceeded the Hong Kong indoor air quality objectives [30]. Incense is a smouldering plant-material and resin product, whereas camphor burns as a volatile fuel, so incense data may over- or under-state camphor emissions: they show the scale and the mechanism, not camphor-specific exposure.

Scenario matters. A brief aarti flame in a ventilated room, repeated or prolonged burning in a small closed shrine room, and temple-staff exposure over many hours are different exposures. Deliberately inhaling burning camphor smoke or vapour as a remedy is a further case: Camphor is absorbed by inhalation [8,10], so it is a direct dose of the compound itself and is not advised. No study located shows that ordinary brief ritual burning causes a particular chronic disease.

Does the form of camphor change what is emitted? Pure natural and pure synthetic camphor are the same fuel molecule, so differences in the main emissions are not expected. Trace impurities could in principle alter minor by-products (for example, a halogen-containing impurity could yield halogenated products), but this is hypothetical and is bounded by the low impurity limits if a product meets them [32]. The additives, coatings and fillers of a marketed tablet, and airflow, burner and wick, are the more

probable drivers of differences between products; claims such as ‘smokeless’ have not been tested (inference).

10.4 Fullerenes and other carbon nanostructures in camphor soot

Does burning camphor form fullerenes? Camphor soot has been shown in the laboratory to contain fullerenes, but this has not been measured under household conditions. In 1994 Mukhopadhyay, Krishna and Sharon reported C_{60} and other fullerenes isolated from a toluene extract of ether-insoluble camphor soot, identified by fast-atom-bombardment mass spectrometry, with X-ray diffraction and electron microscopy of films deposited from the extract [22,23]. Camphor was later developed as a precursor for carbon nanotubes grown by chemical vapour deposition at roughly 550–900 °C in an inert atmosphere with a metal catalyst [24,25], and camphor-derived carbon nanoparticles and carbon dots have been made by acid oxidation [37]. Table 10 summarises these findings and their relevance.

Table 10. Carbon nanostructures reported from camphor and their relevance to household burning.

Material	Conditions	Principal finding	Relevance to ritual burning
Fullerenes (C60 and others) from camphor soot	Soot collected, extracted with solvents; FAB-MS, XRD, SEM [22,23]	C60 and other fullerenes detected	Shows that it is possible; gives no exposure data
Carbon nanotubes	Chemical vapour deposition, about 550–900 °C, inert gas, metal catalyst [24,25]	Multiwall and single-wall nanotubes	Engineered furnace process; not comparable with an open flame
Carbon nanoparticles and dots	Acid oxidation of camphor [37]	Water-soluble nanoparticles and dots	Wet-chemical route; not combustion
Fullerenic carbon in flame soot generally	High-resolution electron microscopy of soot from combustion sources [26]	Curved, fullerene-like layers are common in soot	Not specific to camphor
Fullerenes in smoke or soot from ritual camphor burning	—	No study located	Quantity, particle form and exposure unknown

Two cautions limit what the laboratory result means. First, fullerenic carbon is not specific to camphor: electron microscopy of soot from many sources shows curved fullerene-like layers and closed-shell structures [26], so camphor soot is one example of a general phenomenon and is not evidence that camphor flames are more or less hazardous than other flames. Second, the conditions differ. The laboratory work collected soot in quantity, extracted it with organic solvents and used sensitive mass spectrometry, or grew nanomaterials in a furnace, whereas a ritual flame burns in open air for minutes. No study located reports the fullerene fraction of soot from ritual camphor burning, measures fullerenes in the smoke, or tests whether any would be airborne as free molecules rather than bound within soot particles.

The toxicology of fullerenes does not allow a confident verdict either way. Pristine C_{60} given orally to rats in olive oil showed no chronic toxicity in one study [27], and water-soluble derivatives may behave differently from pristine C_{60} [27]; but a later mouse study found light-dependent toxicity of C_{60} in olive oil and did not reproduce a lifespan benefit [28], and fullerene toxicity is reviewed in [29]. None of these studies concerns inhalation of fullerenic soot from burning camphor. On present evidence the better-established concerns are respirable particles, carbon monoxide and organic combustion products (Section 10.3). The contribution of fullerenic carbon cannot be ranked against them, and it should neither be dismissed nor emphasised until it is measured.

10.5 What depends on the form of camphor and what does not

- **Largely independent of origin:** Acute systemic toxicity of the molecule by ingestion, vapour inhalation and skin absorption, which is driven by dose and route [4,9].
- **Plausibly dependent on origin, untested:** Minor constituents, irritancy and trace combustion by-products from impurities (borneol and terpenoids in natural camphor; camphene, isoborneol and reagents in synthetic camphor).
- **Likely dependent on product and burning conditions:** Smoke, particulate matter, carbon monoxide and organic emissions; residue; and the identity and toxicity of additives.

10.6 Who may be more vulnerable

People with asthma, COPD or cardiovascular disease, infants, young children and older adults may be more affected by smoke and irritant vapours. Young children are at particular risk of ingestion. This review does not claim that ordinary brief ritual use causes a particular chronic disease; camphor-specific long-term epidemiology is limited. The socio-economic modifiers in Figure 7 (housing, ventilation, occupation, safe storage and access to care) apply across all three routes.

10.7 Practical exposure reduction

- **All routes:** Buy products with a named manufacturer, batch number, declared intended use and credible quality documentation.
- **Direct exposure:** Avoid prolonged handling or bedside storage of loose camphor; keep topical products to their declared concentration and away from eyes and broken skin.
- **Ingestion:** Store camphor out of children's reach and away from sugar-like sweets; do not swallow ritual camphor; do not use any camphor product by mouth as a remedy without medical advice. Ingestion is an emergency: seek urgent medical help for ingestion, seizures or breathing difficulty.
- **Combustion emissions:** Do not burn camphor in a small, closed room; open windows or use exhaust ventilation; use the smallest amount consistent with the ritual; avoid prolonged burning near children, older adults or people with respiratory disease; do not deliberately inhale smoke or use burning camphor as medical treatment.
- If heavy black deposition or unusual fumes occur, stop, ventilate, keep the packaging and seek laboratory testing rather than relying on a home flame test.

11. Regulation, standards and policy options

Ritual products, cosmetic ingredients, topical medicines and food or flavour ingredients fall under different frameworks and are not interchangeable. The socio-economic analysis points to low-cost, equity-oriented measures:

- Label intended use, concentration, manufacturer and lot, with a clear warning against ingestion and child-resistant or at least child-deterrent packs for tablet jars.
- Subsidised or shared analytical testing for small packers and tablet makers, so compliance does not depend on firm size.
- State-stratified market surveillance with anonymised public results for identity, purity, adulterants and burning emissions.
- Public-health messaging on ventilation and safe storage through temples, schools and community health workers, aimed at small, poorly ventilated homes.
- Clarify GST and HSN classification for ritual, medicinal and industrial camphor to reduce misdeclaration.
- Collect labour data (wages, occupational exposure) for tablet pressing, packing and temple work, as is done for incense.
- Require labels to state origin (natural, synthetic or blended) and use category (ritual, topical or food), with route-specific warnings: not for ingestion on ritual products, declared concentration on topical products, and ventilation advice for burning.
- Define a specification for 'edible' camphor and test whether 'smokeless' and 'natural' claims hold before they are allowed on labels.

12. Research gaps and proposed study design

- **Market surveillance:** Stratified sampling by state, urban or rural setting, brand, price tier and festival season.

- **Chemical quality:** GC–MS and GC–FID profiles, enantiomeric composition, ash, hexamine screening and other evidence-led tests.
- **Burning emissions:** Chamber tests of PM1/PM2.5/PM10, black carbon, CO, VOCs and carbonyls under defined ventilation.
- **Health evidence:** Exposure assessment in frequent users, temple staff and tablet workers, with confounders (such as cooking fuel) and ethical safeguards.
- **Economics:** Official volume data by grade, margin analysis along the chain, and household-level use and expenditure surveys.
- **Equity:** Compare exposure and poisoning risk by income, housing and child-safety practices.
- **Comparative toxicology:** Impurity profiles and, in vitro, irritancy and metabolism of natural (+)-camphor, synthetic racemic camphor and commercial tablets; no such study was located.
- **Soot composition:** Chamber burns of standardised natural, synthetic and commercial tablets, measuring PM, black carbon, CO, VOCs, carbonyls, PAHs and solvent-extractable fullerenes in airborne and settled soot.
- **Poisoning surveillance:** Poison-centre and hospital data on camphor ingestion in India by product type and age.

13. Conclusions

Camphor is culturally central and cheap in India, with a domestic synthetic-manufacturing base and net exports on the main synthetic tariff line. The earlier reported claim of heavy import dependence is not supported by the tariff data located. Socio-economically, the key points are that demand is broad and low-cost, that affordability is not the main barrier (quality information is), that livelihoods and occupational exposure in the informal tail of the chain are undocumented, and that health risks (ingestion by children, particles in poorly ventilated rooms) are likely to be unevenly distributed. Soot is a warning of particle release, not proof of adulteration. The strongest practical steps are to buy traceable products, avoid enclosed-space burning, prevent ingestion and fund independent testing and surveillance.

Natural, synthetic and marketed camphor share the same active molecule, so the ingestion hazard should not be judged by origin or label; differences in combustion emissions are more likely to arise from product formulation and burning conditions, but no study compares them. Health risk should be assessed by route: ingestion is the best-documented danger, inhalation of combustion products is supported only by incense proxies, and fullerenic carbon has been isolated from camphor soot in the laboratory, but its quantity and significance in household burning are unmeasured.

Declarations

1. Conflict of Interest

The author declares that there are no conflicts of interest, financial or otherwise, that could have influenced the preparation, interpretation or publication of this manuscript.

2. Funding Statement

This research received no specific financial support or external funding from any government, commercial, industrial or non-governmental funding agency.

3. Ethical Approval

Ethical approval was not required because this manuscript is a narrative review based on previously published scientific literature, publicly available reports, industry information, trade data, and other secondary sources. No human participants, animals, or personal identifiable data were directly involved.

4. Informed Consent

Not applicable. No human participants were recruited, and no primary personal or clinical data were collected.

5. Data Availability Statement

No new datasets were generated or analysed during the preparation of this manuscript. The information presented is based on previously published research, publicly accessible reports, literature, and secondary sources.

6. Author Contributions

The author was responsible for conceptualisation, literature collection, analysis and interpretation of information, manuscript preparation, critical revision and final approval of the manuscript.

7. Use of Artificial Intelligence (AI) Tools

AI-assisted tools were used to support literature organisation, manuscript structuring, language refinement and presentation. The author critically reviewed and verified the content of the manuscript.

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9. Disclaimer

The views and interpretations expressed in this manuscript are those of the author. The discussion of health implications associated with camphor burning is intended for scientific and educational purposes and should not be interpreted as individual medical advice. The review does not endorse the use of adulterated or unidentified camphor products.

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