



From field to fragrance: A review on post-harvest technologies and value addition in jasmine

Nandana A¹, Thamaraiselvi S P^{1*}, Karthikeyan S², Vinothkumar B³ & Sritharan N⁴

¹Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

²Department of Fruit Science, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

³Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

⁴Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

*Correspondence: Thamaraiselvi S P, thamaraiselvi.sp@tnau.ac.in

Abstract

Jasmine (*Jasminum* spp.) is a valuable flower crop grown widely in tropical and subtropical regions for its cultural, ornamental and industrial importance. However, its high perishability, rapid aging and loss of fragrance create significant challenges for post-harvest handling, marketability and export potential. This review brings together current knowledge on the post-harvest biology of jasmine flowers. It focuses on key biochemical changes, including membrane damage, oxidative stress, enzymatic browning and the timing of the pathways that produce fragrance. The effectiveness of various methods, such as pre-cooling, cold storage, modified atmosphere packaging (MAP), controlled atmosphere storage (CA), chemical preservatives, natural anti-aging agents and biodegradable coatings, is critically assessed for their ability to keep flowers fresh, colourful, firm and aromatic. Emerging green extraction technologies, such as supercritical CO₂ extraction, ultrasound-assisted extraction and microwave-assisted extraction (MAE), are explored in relation to value addition in perfumery, cosmetics, hair oils, teas and functional foods. Supply chain challenges include inadequate cold chain infrastructure, inconsistent grading and price volatility. Post-harvest losses of 15–35 % of gross production are common across producing regions, underscoring the economic urgency of improved handling and cold-chain infrastructure. Lastly, this review identifies key research gaps in post-harvest storage, molecular regulation of senescence, sustainable processing and artificial intelligence (AI)-assisted quality assessment. By integrating current advances in post-harvest physiology, green extraction technologies and value addition, it provides a comprehensive framework and outlines future research priorities for enhancing the jasmine value chain. Future directions are suggested to strengthen jasmine value chains from harvest to value addition.

Keywords: fragrance retention; jasmine (*Jasminum* spp.); modified atmosphere packaging; post-harvest physiology; shelf-life extension; value addition

Received: 03 July 2026. **Accepted:** 15 August 2026. **Published:** Version 1.0: 22 October 2026.

Cite this article: Nandana A, Thamaraiselvi SP, Karthikeyan S, Vinothkumar B, Sritharan N. From field to fragrance: A review on post-harvest technologies and value addition in jasmine. *Plant Science Today*. 2026; 13(sp9): 1-16. <https://doi.org/10.14719/pst.16513>

1. Introduction

Jasmine (*Jasminum* spp.) is one of the oldest and most valued fragrant flowers in human history. It is widely grown in tropical and subtropical areas for its ornamental, cultural and industrial uses (1, 2). It is often called the "queen of fragrance". The genus *Jasminum* comprises approximately 200 species distributed across tropical and subtropical regions of the world, although species numbers vary among taxonomic treatments (3, 4). Among these, *Jasminum sambac* (L.) Aiton, *Jasminum grandiflorum* L. and *Jasminum auriculatum* Vahl are the principal species cultivated commercially in South and Southeast Asia (5, 6).

Jasmine flowers are indispensable in religious and social ceremonies, hair adornment, garland making and as cut or loose flowers, embedding them deeply in the socio-cultural fabric of countries such as India and

Indonesia (7). In perfumery and allied industries, jasmine essential oil, concrete and absolute are high-value ingredients used in luxury perfumes, cosmetics, aromatherapy products, flavoured teas and food flavorings, with benzyl acetate and related volatiles defining their unique, difficult-to-imitate aroma profile (8, 9).

Tamil Nadu and Karnataka in India, parts of Egypt, Morocco and China are some of the biggest producers of jasmine. These countries are part of a rapidly growing global jasmine value chain that distributes loose flowers and processed products to markets in the USA, Europe, the Gulf countries and East Asia (10, 11).

Adding value by extracting essential oils, concrete, absolutes, teas and skincare formulations greatly increases profitability and export potential. This

is driven by the high market premium commanded by jasmine absolute, which significantly enhances profit margins for processors and perfumeries (10). However, jasmine flowers are highly perishable, with rapid browning, loss of fragrance and short post-harvest life posing major constraints, leading to substantial quantitative and qualitative losses between farm and market (12).

This review was compiled by searching Scopus, Web of Science and Google Scholar for peer-reviewed articles published between 2000 and 2025, using combinations of the search terms 'jasmine', 'Jasminum', 'post-harvest physiology', 'senescence', 'cold storage', 'modified atmosphere packaging (MAP)', 'essential oil extraction' and 'value addition'. Studies reporting primary experimental data on jasmine post-harvest handling, storage, or processing were included; studies on unrelated ornamental species without direct relevance to jasmine and non-peer-reviewed sources were excluded.

Inadequate grading, packaging, cold storage and transport, along with price fluctuations and quality demands for exports, make it even more important to have scientifically standardised post-harvest technologies from harvest to value addition. These technologies should include optimised chemical treatments, packaging systems, cold chain management and advanced extraction and processing methods to reduce losses, stabilise quality and maximise returns across the jasmine value chain (8).

Botanical and commercial profile of jasmine

Commercially important *Jasminum* species

Extant literature identifies *J. sambac*, *J. grandiflorum* and *J. auriculatum* as the main commercial species. They are grown on a large scale for fresh markets and for essential oil extraction (concrete/absolute). *Jasminum multiflorum* (Burm.f.) Andrews and *Jasminum nitidum* Skan are becoming less common, but they are economically promising species for loose flowers and year-round use (12, 13).

Flower characteristics affecting post-harvest life

Jasmine flowers are extremely perishable; rapid browning, loss of fragrance and uncontrolled bud opening are the main quality losses (14). Shelf life is determined by petal delicacy, moisture content, relative water content, membrane integrity, ethylene sensitivity, phenolic content and other physiological factors influencing post-harvest deterioration (8). Colour and brightness decline quickly due to photo-oxidative stress and pigment degradation, with pedicels browning faster than petals (14). Volatile emission and fragrance depend on maturity and freshness; loss of key volatiles (e.g., benzyl acetate, linalool, α -farnesene) reduces market value during storage (15).

Stage of harvested product

Commercially, jasmine flowers are marketed primarily as unopened flower buds or fully opened flowers,

depending on their intended end use in the fresh flower market or processing industry (16). Many post-harvest experiments deliberately treat and pack flower buds (e.g., *J. sambac* cv. Gundumalli, *J. nitidum*, *J. multiflorum*) because buds show longer shelf life and lower opening index than open flowers under cold storage or chemical treatments (13). Dehydrated whole flowers (mostly open) are also produced for dried products and extraction, with method-dependent retention of volatiles and phenolics (10).

Market and industrial relevance

Jasmine flowers are high-value commercial floricultural products widely used in South and Southeast Asia for garlands, religious offerings, ornamentation and as raw materials for perfume, cosmetics, aromatherapy and food industries (17). Essential oil and concrete from *J. grandiflorum* and *J. sambac* are particularly prized in perfumery; Indian *J. grandiflorum* oil compares favourably with Spanish jasmine in yield and quality (1). Value addition strategies such as drying, essential oil extraction, nanoemulsion-based coatings and biodegradable packaging can enhance shelf life, reduce post-harvest losses and improve the market value of jasmine flowers through better preservation and diversified product development (18). Jasmine trade already exceeds hundreds of millions of USD globally and supports significant rural employment, especially for women in harvesting, grading and garland making (10).

Post-harvest physiology of jasmine flowers

Biochemical changes after harvest

Jasmine flowers undergo rapid biochemical transformations immediately following harvest, primarily characterised by accelerated metabolic activities to sustain cellular processes (19). The detachment from the mother plant triggers stress-induced responses, including increased production of reactive oxygen species (ROS) and activation of senescence-associated metabolic pathways (20). Post-harvest jasmine flowers exhibit significant alterations in biochemical constituents, with a progressive decline in soluble proteins and concurrent increases in proteolytic enzyme activities that facilitate protein degradation (21).

Absciscic acid (ABA) levels in jasmine (*J. sambac*) petals increase dramatically during senescence, rising to 91.27 pmol g⁻¹ in untreated flowers, indicating hormonal regulation of senescence processes (22). Total phenolic content undergoes dynamic changes during flower development and senescence, with the lowest levels measured in buds and partially opened flowers (50.90 µg/g) but the highest in fully opened flowers (61.80 µg/g), suggesting phenolic accumulation as flowers progress toward senescence (22, 23). The water balance in harvested jasmine flowers is progressively disrupted due to reduced water uptake capacity and continued transpirational losses, leading to turgor pressure decline and wilting symptoms (19). The effect of pre-treatment and packaging materials on total phenols in jasmine is shown in Fig. 1.



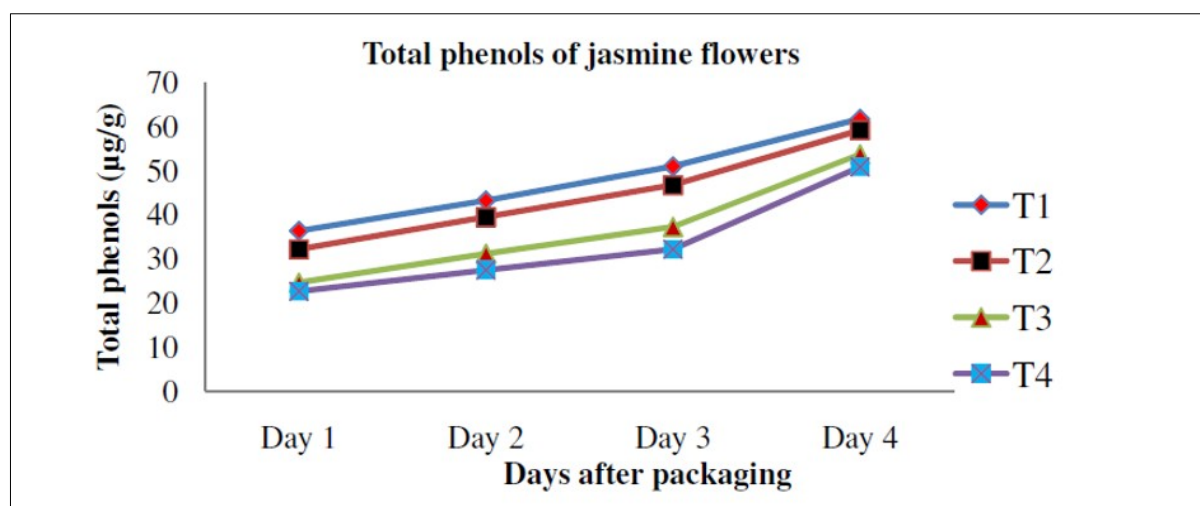


Fig. 1. Effect of pre-treatment and packaging materials on total phenols in jasmine flowers (22).

Respiration and transpiration patterns

Jasmine flowers exhibit high metabolic activity post-harvest, characterised by elevated respiration rates that significantly deplete carbohydrate reserves and accelerate senescence (21, 24). The respiratory metabolism in jasmine is temperature-dependent and shows significant temporal and quantitative changes. In excised *J. sambac* flowers, linalool emission increases from 15.76 mg/kg fresh weight at 2 hr post-harvest to a peak of 22.03 mg/kg at 8 hr, before declining to 12.66 mg/kg at 16 hr. α -Farnesene shows a different pattern, with emissions increasing progressively from 1.45 mg/kg at 2 hr to 30.66 mg/kg at 8 hr and remaining at 30.71 mg/kg at 16 hr post-harvest (25).

The biosynthesis of major volatiles is catalysed by specific enzymes: α -farnesene is synthesised through the mevalonate (MVA) pathway, in which 3-hydroxy-3-methylglutaryl-CoA reductase (HMGR) functions as the rate-limiting enzyme, followed by the sequential actions of farnesyl pyrophosphate synthase

(FPS) and terpene synthase (TPS); linalool is produced through the methylerythritol phosphate (MEP) pathway; and benzyl acetate is formed by benzyl alcohol acetyltransferase (BEAT) enzymes (Fig. 2) (25–27).

The expression levels of genes encoding these biosynthetic enzymes show temporal patterns that closely match volatile emission profiles, with peak gene expression coinciding with maximum aroma compound production in post-harvest jasmine flowers (25, 27). Temperature significantly influences both volatile biosynthesis and degradation rates, with elevated temperatures accelerating volatile loss while refrigeration can suppress emission but also inhibit flower opening and full fragrance development (24, 25). Heat shock proteins (HSPs) may play a protective role in maintaining aroma biosynthesis under high-temperature stress conditions common during post-harvest handling of jasmine flowers (26, 27). Major volatile compounds in jasmine and their post-harvest emission patterns are summarised in Table 1.

Table 1. Major volatile compounds in jasmine and their post-harvest emission patterns

Volatile compound	Chemical class	Emission pattern (<i>Jasminum sambac</i>)	Biosynthetic pathway	References
α -Farnesene	Sesquiterpene	1.45 mg/kg (2 hr) → 30.66 mg/kg (8 hr) → 30.71 mg/kg (16 hr)	MVA pathway (HMGR, FPS, TPS)	(68, 25)
Linalool	Monoterpene	15.76 mg/kg (2 hr) → 22.03 mg/kg (8 hr) → 12.66 mg/kg (16 hr)	MEP pathway	(68, 25)
Benzyl acetate	Benzenoid ester	Low (early) → 16.68 mg/kg (8 hr) → 12.66 mg/kg (16 hr)	BEAT enzyme (phenylpropanoid)	(25, 27)
Benzyl alcohol	Benzenoid	Present throughout, precursor to benzyl acetate	Phenylpropanoid pathway	(15, 25)
Indole	Nitrogen-containing	Component of characteristic jasmine note	Tryptophan-derived	(15, 25)
Methyl anthranilate	Anthranilate ester	Contributes to fruity-floral note	Anthranilate pathway	(25)

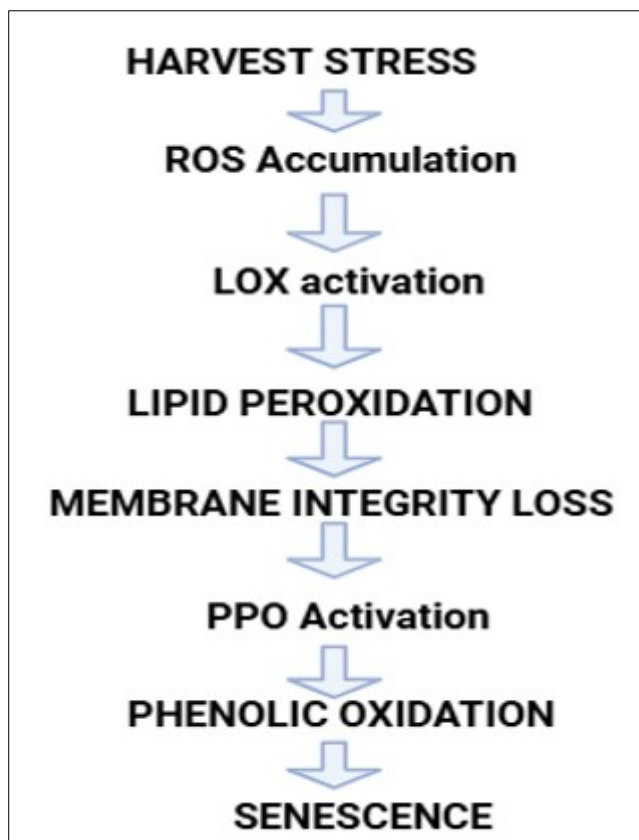


Fig. 2. Biochemical and enzymatic pathways driving post-harvest senescence in jasmine.

Primary processing technologies

Pre-cooling and temperature management

Immediately after harvest, jasmine flowers should be pre-cooled using forced-air cooling or room cooling to rapidly remove field heat before storage. Following pre-cooling, flowers should be stored at 5–10 °C in polyethylene or polypropylene packaging to maintain freshness and extend shelf life and maintain freshness, colour and fragrance compared with ambient storage

(24, 28). Combining low temperature with suitable chemical pre-treatments (e.g., boric acid, sucrose, GA₃ or nanoemulsified essential oils) further delays petal browning, lowers PPO/PAL/POD activities and sustains visual quality indices in *J. nitidum*, *J. multiflorum* and *J. sambac* (13, 28). Freshness index of jasmine flowers is shown in Fig. 3.

Cleaning and sorting techniques

In loose flowers, removal of damaged, discoloured, or partially opened buds at collection points helps reduce marketable losses and improves the effectiveness of subsequent storage, chemical treatments and packaging operations by ensuring better-quality flowers enter the post-harvest chain (13). In commercial jasmine chains, traders often perform basic sorting of buds before packing in plastic bags with ice or cold storage, although full grading standards are rarely followed; improved systematic sorting is recommended to reduce quality variation and post-harvest losses (10, 29).

Grading and quality assessment parameters

Grading of jasmine flowers is generally based on measurable quality parameters including bud size, degree of flower opening, colour uniformity, freshness, freedom from browning and mechanical damage and absence of pest or disease symptoms, which directly affect market price and exportability (10). Quantitative quality assessment increasingly uses indices such as freshness index, flower opening index, colour retention index, fragrance score and physiological loss in weight, together with moisture content, relative water content, membrane integrity and total phenols to evaluate post-harvest treatments and storage regimes (5, 28). Computer-vision colour indices (e.g., hue, chroma, vegetative index (VEG), colour index (COM), colour index of vegetation extraction (CIVE)) have also been modelled to describe jasmine petal browning kinetics non-destructively, offering objective tools for grading and shelf-life prediction (14).

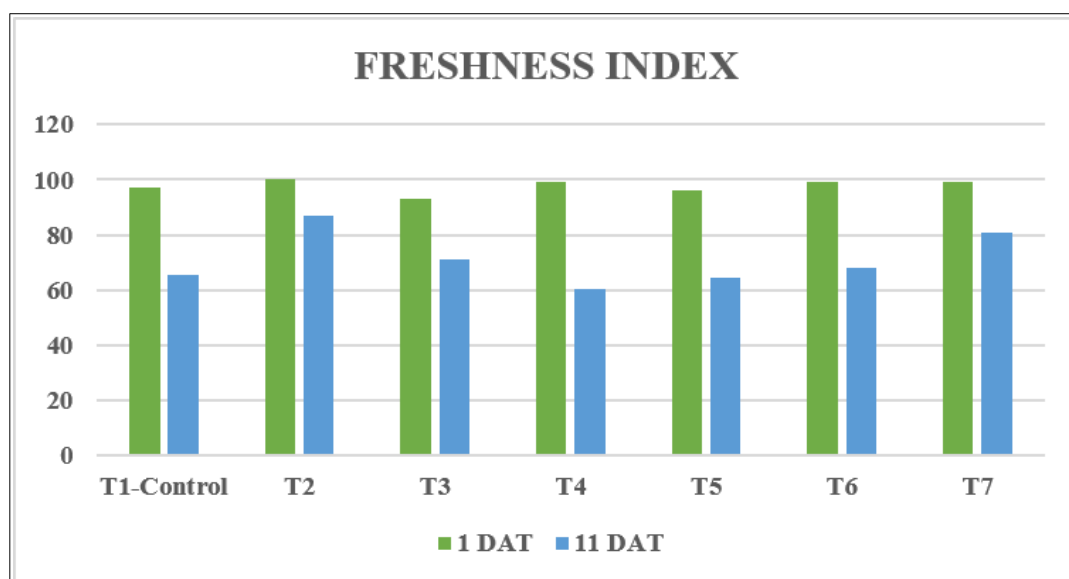


Fig. 3. Freshness index of jasmine flowers under different treatments (32).

Initial handling and transportation

Gentle harvesting of flower buds at the commercial tight-bud stage, characterised by fully developed, firm, unopened buds showing characteristic mature bud colour before anthesis, is recommended to maximise vase life and fragrance retention and rapid transfer under shade to collection centres is critical to limit mechanical injury, water loss and ethylene exposure, all of which shorten the brief post-harvest life of jasmine flowers (8, 27). In both Philippine and Indian jasmine chains, flowers are typically placed in plastic bags and transported in Styrofoam/thermocool boxes with crushed or gel ice to maintain low temperatures during marketing; however, inconsistent grading, mixed containers and inadequate cold-chain infrastructure still contribute substantially to quality deterioration and economic losses (10, 29). The integrated post-harvest handling stages, interventions and their impact on quality parameters are summarised in Fig. 4.

Preservation and storage technologies

Cold storage systems and optimal conditions

Cold storage is one of the most widely adopted and effective strategies for extending the vase life and marketable quality of jasmine flowers (*J. sambac* and allied species). The optimal cold storage temperature for jasmine buds and open flowers generally ranges between 8 °C and 15 °C; this range represents the general optimum for *J. sambac* and allied species; *J. grandiflorum* has been reported to tolerate slightly lower temperatures (5–10 °C) without chilling injury in some studies, while species-specific data for *J.*

multiflorum remain limited, with relative humidity maintained at 85–95 % to minimise water loss and wilting. Temperatures below 8 °C are generally avoided as they can induce chilling injury, surface discoloration, petal blackening and compromised fragrance profile. Studies have demonstrated that pre-cooling immediately after harvest, combined with maintenance of the cold chain throughout the distribution process, can extend the post-harvest life of jasmine flowers by 2–3 days compared to ambient storage (30). Lowering the storage temperature substantially reduces the rates of respiration, ethylene biosynthesis and enzyme-mediated senescence reactions that collectively accelerate petal deterioration in *J. sambac* and *J. grandiflorum* (31, 32). The maintenance of an unbroken cold chain from farm to market has been repeatedly emphasised as a critical requirement for commercial jasmine operations, especially in export contexts where transit durations extending beyond 24 hr can drastically diminish marketable quality without appropriate low-temperature support (31).

The passive MAP treatment at 2 °C resulted in a longer, chilling-injury-free storage outcome (21), compared with the general 8–15 °C cold-storage range, which extends shelf life by only 2–3 days (30), indicating that the combination of low temperature and modified atmosphere provides a greater benefit than temperature control alone. The 42.88-hr export protocol using boric acid and gel-ice packaging is in the same temperature band but achieves its outcome through chemical pretreatment, not temperature alone, so it is not directly comparable on shelf-life days but is consistent in reliance on unbroken cold-chain maintenance (24).

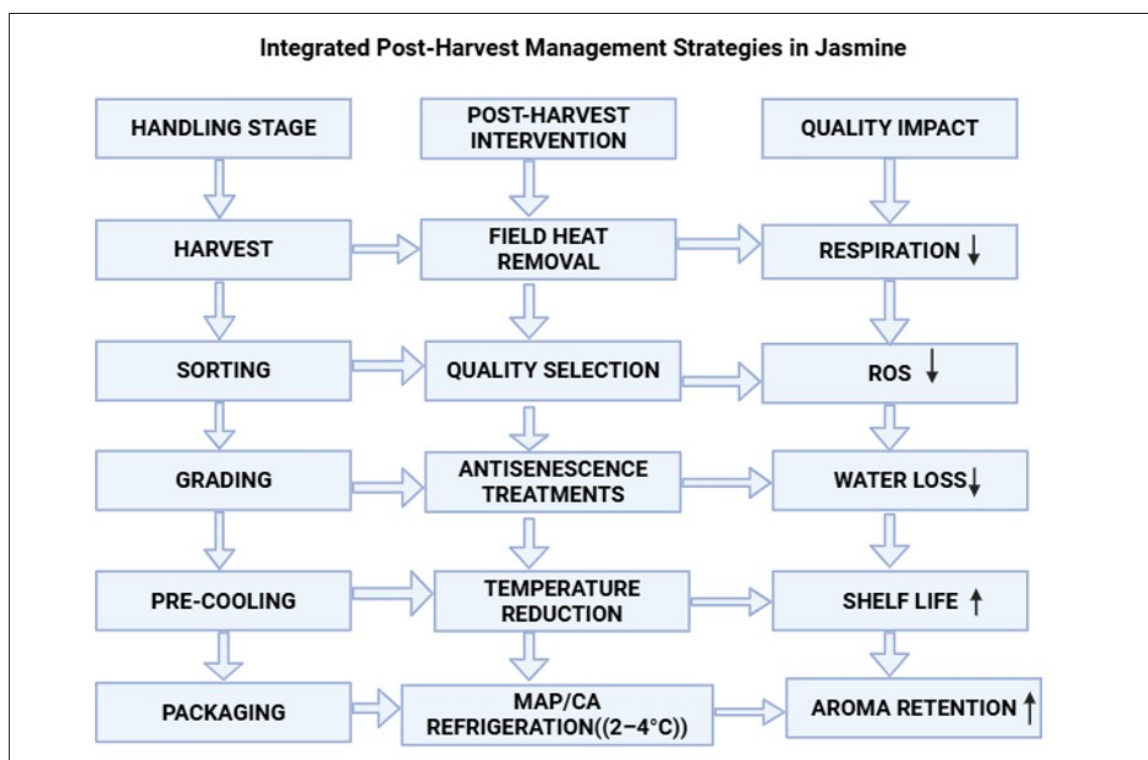


Fig. 4. Integrated post-harvest management strategies in jasmine.

Flow chart of packaging technology for short-distance markets is presented in Fig. 5. Flow chart for packaging technology for long-distance market is represented in Fig. 6. Optimal cold storage conditions for different jasmine species are summarised in Table 2.

Modified atmosphere packaging (MAP)

Modified atmosphere packaging (MAP) represents a significant technological advancement in jasmine post-harvest management, functioning by altering the gaseous environment within sealed packaging to retard physiological processes responsible for flower deterioration. In passive MAP, the modified atmosphere is created naturally through the combined action of product respiration, which consumes oxygen and generates carbon dioxide and the selective gas permeability of the packaging film, which acts as a barrier to gas exchange between the interior and exterior of the package (21).

The impact of passive MAP using polypropylene film of 24-micron thickness was

evaluated on jasmine (*J. sambac*) flower bud storage at temperatures of 2 °C, 5 °C and 10 °C and demonstrated that buds stored under passive MAP at 2 °C exhibited superior freshness, minimal physiological loss in weight (PLW %) and longer shelf life without any chilling injury symptoms such as browning or wilting compared to non-MAP-stored controls (21). The chemical treatment of jasmine flowers was further demonstrated with 4 % boric acid combined with packing in aluminium foil-lined corrugated fibre board boxes under gel-ice cold conditions effectively achieved a commercially viable shelf life of 42.88 hr inclusive of a 36-hr air transit period, with maximum freshness index of 70–90 %, minimum flower opening index of 10.5–50 % and maximum colour retention index of 77.77–88.88 % (31). The incorporation of ethylene absorbents, desiccants, or antimicrobial sachets within MAP pouches as active packaging components further enhances storage outcomes beyond what passive gas modification alone can achieve.



Fig. 5. Flow chart of packaging technology for short distance market (80).



Fig. 6. Flow chart of packaging technology for long distance market (80).

Table 2. Optimal cold storage conditions for different jasmine species

Species/Form	Optimal Temp. (°C)	Relative humidity (%)	Extended shelf life	Key benefits	Strength of evidence	References
<i>Jasminum sambac</i> (buds)	2–5	85–95	Up to 16 days (vs. 4 days ambient)	Minimal browning, high freshness	Robust (multiple studies/species)	(21, 24)
<i>Jasminum sambac</i> (passive MAP)	2	85–95	Superior to 5 °C and 10 °C	No chilling injury, low physiological loss in weight (PLW)	Preliminary (single study)	(21)
<i>Jasminum grandiflorum</i> (buds)	2–10	85–95	Extended with chemical treatments	Fragrance preservation critical for oil	Preliminary (single study)	(32)
<i>Jasminum sambac</i> (export)	5 ± 2 (gel-ice)	Controlled	42.88 hr (36 hr transit + storage)	70–90 % freshness, high colour retention	Preliminary (single study)	(31)
General jasmine	8–15	85–95	2–3 days extension	Reduced respiration, delayed senescence	Preliminary (single study)	(30)

The freshness results for passive MAP at 2 °C are qualitative (better freshness, no chilling injury) and not quantified in days, making it more difficult to directly benchmark with the shelf life of 42.88 hr (21) defined quantitatively with boric acid plus gel-ice packaging (24). However, both approaches point to the same underlying principle that low temperature combined with a barrier to gas or moisture exchange is better than low temperature alone. This supports the cold-storage analogy.

Controlled atmosphere storage

To date, few studies have applied true active controlled atmosphere (CA) storage to jasmine specifically; most available evidence derives from passive MAP systems and the potential of active CA storage for jasmine remains largely unexplored. Controlled atmosphere storage maintains precise concentrations of O₂ (2–5 %), CO₂ (5–10 %) and N₂ continuously throughout the storage period through active monitoring and regulation, distinguishing it from the passive equilibration characteristic of MAP systems (31).

For jasmine, kinetic models of colour degradation suggest that integrating gas-composition sensors with temperature and humidity monitoring could help define CA set-points that minimise browning and pigment loss during storage (14). Controlled atmosphere storage also supports supply-chain flexibility. By slowing physiological deterioration at low temperature and optimised gas composition, producers can buffer market fluctuations and coordinate harvest with export logistics, a strategy already recommended for high-value cut-flower industries operating long cold chains (33).

Because no active CA trials with quantified shelf-life or freshness-index outcomes have yet been conducted on jasmine, the O₂/CO₂ set points discussed here cannot be benchmarked against the MAP results or the chemical treatments; any performance comparison at this stage would be speculative rather than evidence-based.

Use of preservatives and anti-senescence agents

Chemical anti-senescence treatments are central to jasmine post-harvest management. In *J. grandiflorum*, bud pretreatment with silver nanoparticles (20 ppm), boric acid (4 %), sucrose (4 %), naphthalene acetic acid (NAA) (100 ppm), 6-Benzyladenine (BA) (500 ppm), or α -Aminoisobutyric acid (α -AIB) (20 μ M), applied by quick dipping before packing in polypropylene bags, significantly extended shelf life under ambient and cold storage; silver nanoparticles produced the highest freshness index, colour retention and fragrance preservation up to 11 days (28). Effect of pretreatment on shelf life (days) of jasmine flower during ambient storage is represented in Fig. 7.

For *J. multiflorum*, a combined solution of sucrose (20 %), gibberellic acid (GA₃) (100 ppm) and boric acid (2 %) extended shelf life to approximately 4.4 days. The study evaluated only the combined treatment, which maintained a higher freshness index, phenolic content, lower browning and reduced microbial growth under ambient conditions, with higher freshness index, phenolic content, lower browning and reduced microbial growth, demonstrating synergistic effects of carbohydrate supply, growth regulator and micronutrient on delaying senescence (13).

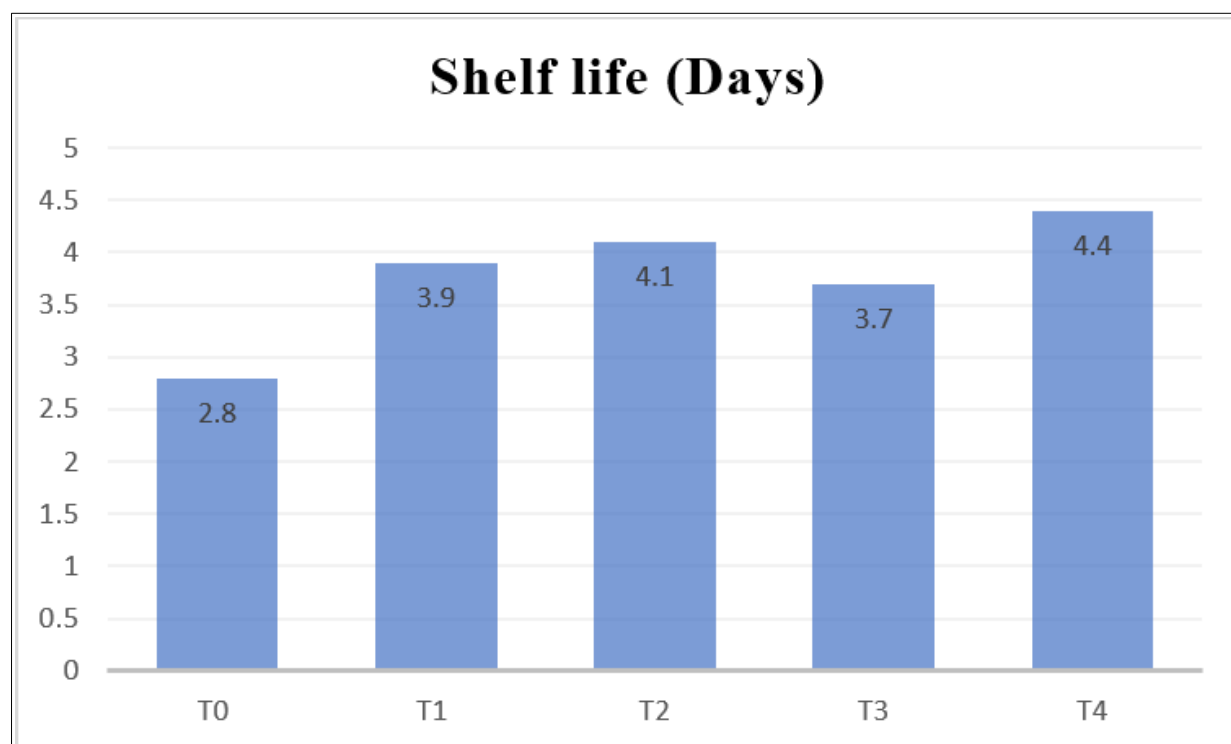


Fig. 7. Effect of pretreatment on shelf life (days) of jasmine flower during ambient storage (13).

The sucrose + GA₃ + boric acid combination in *J. multiflorum* at approximately 4.4 days extends shelf life for a substantially shorter duration than the 11-day maximum reported for silver nanoparticle pretreatment in *J. grandiflorum* (36), but the two results are from different species and cannot be interpreted as a direct efficacy ranking. Both are better than the traditional 4 % boric acid-only export protocol (approximately 43 hr), indicating that combination or nanoparticle-based treatments provide a significant improvement over single-agent chemical treatment alone (18). Traditional export protocols for *J. sambac* have used 4 % boric acid plus cold packaging to extend shelf life to approximately 43 hr but concerns over worker and consumer safety are prompting shifts towards safer alternatives (18).

Natural anti-senescence agents are emerging. Nanoemulsions of *J. officinale* essential oil (1–2 mg mL⁻¹) applied to *J. sambac* flowers by soaking for 5 min, followed by refrigerated storage in polyethylene bags, significantly delayed petal browning, maintained high freshness and colour indices and suppressed phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO) and peroxidase (POD) activities, indicating effective control of enzymatic browning (12). Chitosan-based biodegradable films not only act as physical packaging but may also provide mild antimicrobial and barrier functions, further supporting

shelf-life extension in jasmine without synthetic chemicals (18). Chemical Preservatives and anti-senescence treatments for jasmine is represented in Table 3.

Across the treatments reviewed, boric acid and sucrose-based formulations show the most consistent quantitative benefit, being independently supported across multiple studies and species and converging on reduced browning, extended freshness and moderate shelf-life gains (13, 31). By contrast, the most dramatic single figure, the 11-day extension from silver nanoparticle pretreatment, rests on one study in one species and should be treated as preliminary until replicated (32). The same caution applies to the 4.4-day sucrose + GA₃ + boric acid result (13), the essential oil nanoemulsion and chitosan coating outcomes (12, 18) and the general 2–3-day cold-storage figure, each from a single source (30). With no active CA trials yet quantified for jasmine, any projected CA benefit remains speculative. Overall, the evidence base is strongest for combination chemical treatments and cold-chain maintenance and weakest for nanoparticle and nanoemulsion-based interventions despite their standout figures. These single-source results warrant replication before being treated as benchmarks in future reviews.

Table 3. Chemical preservatives and anti-senescence treatments for jasmine

Treatment	Concentration	Species	Key effects	Shelf Life extension	Strength of evidence	References
Silver nanoparticles	20 ppm	<i>Jasminum grandiflorum</i>	Highest freshness, colour retention, fragrance preservation (up to 11 days)	Best among tested treatments	Preliminary (single study)	(32)
Boric acid	2–4 %	<i>Jasminum sambac</i> , <i>Jasminum multiflorum</i>	Reduced browning, microbial control, extended freshness	43 hr (with cold chain)	Robust (multiple studies/species)	(13, 31)
Sucrose	4–20 %	<i>Jasminum grandiflorum</i> , <i>Jasminum multiflorum</i>	Energy supply, higher phenolic content, osmotic stress reduction	Synergistic with gibberlin (GA ₃)	Robust (multiple studies/species)	(13, 32)
Gibberellic acid (GA ₃)	100 ppm	<i>Jasminum multiflorum</i>	Delayed senescence, maintained freshness index	4.4 days (with sucrose + boric acid)	Preliminary (single study)	(13)
NAA (Naphthalene acetic acid)	100 ppm	<i>Jasminum grandiflorum</i>	Reduced ethylene response, delayed abscission	Moderate extension	Preliminary (single study)	(32)
Benzyl adenine (BA)	500 ppm	<i>Jasminum grandiflorum</i>	Cytokinin effect, delayed senescence	Moderate extension	Preliminary (single study)	(32)
α-Aminoisobutyric acid (α-AIB)	20 μM	<i>Jasminum grandiflorum</i>	Ethylene biosynthesis inhibitor	Moderate extension	Preliminary (single study)	(32)
Jasmine essential oil nanoemulsion	1–2 mg/mL	<i>Jasminum sambac</i>	Natural alternative, delayed browning, suppressed PAL/PPO/POD activities	Significant with refrigeration	Preliminary (single study)	(12)
Chitosan coating	Biodegradable film	<i>Jasminum sambac</i>	Antimicrobial, barrier function, eco-friendly alternative to synthetics	Shelf-life extension demonstrated	Preliminary (single study)	(18)

PAL: phenylalanine ammonia-lyase; PPO: polyphenol oxidase; POD: peroxidase.



Extraction methods for jasmine: Traditional and emerging approaches

Jasmine fragrance is captured through several traditional methods. Enfleurage, involving fat absorption of floral volatiles followed by alcohol washing, offers the highest aroma fidelity but is labour-intensive (2, 34, 35). Steam distillation, though economical and scalable, risks thermal degradation of heat-sensitive constituents (36–38). Solvent extraction using ethanol or hexane yields aromatic concretes and absolutes with better preservation of thermolabile compounds, though solvent residues remain a concern (39). Pre-extraction drying and curing further influence oil yield, with excessive heat causing loss of key volatiles (40).

Among emerging technologies, supercritical CO₂ extraction (SFE) at ~200 bar and 325 K achieves approximately 12 % oil yield with superior aroma quality and minimal thermal degradation (41). Ultrasound-assisted extraction (UAE) and microwave-assisted extraction (MAE) offer rapid, energy-efficient alternatives, with UAE recovering higher phenolics (~211 mg/g) and flavonoids (~90 mg/g) than MAE from jasmine leaves (42, 43). Water-based and compressed fluid approaches, along with solar drying as a low-energy pre-treatment, further support sustainable, solvent-free processing chains (44, 45).

Jasmine-based consumer products

Jasmine absolute and essential oil are core ingredients of high-value fine fragrances, where benzenoids and terpenoids (benzyl acetate, linalool, jasmone) provide the characteristic diffusive floral note (15, 46). Jasmine extracts are incorporated into skincare and cosmeceutical formulations for fragrance plus antioxidant, anti-tyrosinase and skin-brightening activities, using SFE-based fractions to balance scent with bioactivity and safety (47). Prototype products such as jasmine-based facial cleansers and skin-friendly perfumes (with other botanicals) demonstrate the feasibility of natural jasmine fragrances with low irritation and good stability in cosmetic systems (48).

Hair oils, attars and incense

Jasmine concretes and attars substantially increase value density, contributing to enhanced economic returns from floral biomass. In India and the Middle East, jasmine concretes/absolutes are blended with sandalwood or carrier oils to prepare attars and perfumed hair oils, using *J. sambac*, *J. auriculatum* and *J. grandiflorum* as principal industrial species (49). Concrete from *J. grandiflorum* and *J. multiflorum* is used to perfume traditional hair oils and incense sticks, where waxy components help fix volatile benzenoids and long-chain hydrocarbons contribute to burn characteristics (10, 49). Economic analyses highlight that converting loose flowers into oil/attars dramatically increases value density (e.g., several tonnes of flowers to 1 kg oil), improving transport and export potential for traditional hair-oil and incense industries (50).

Flavoured tea and food applications

Jasmine flowers, especially *J. sambac*, are used to scent jasmine tea typically over a scenting period of approximately 12–18 hr per scenting cycle, during which processed tea adsorbs volatiles like benzyl acetate and linalool from fresh blooms to create a stable beverage product (50, 51). Jasmine flower extracts with defined antioxidant activity and acceptable cytotoxicity profiles are proposed as functional food or beverage ingredients, supporting applications beyond tea into wider nutraceutical formulations (13, 47). Traditional use of jasmine in teas and flavoured drinks adds value to surplus flowers, reducing post-harvest losses while meeting consumer demand for natural aromatised foods in Asian markets (13, 51).

Supply chain, marketing and socio-economic aspects

Marketing channels and price dynamics

Jasmine flowers are marketed through multi-tiered channels involving up to four intermediary stages (farmers → commission agents → wholesalers → retailers/exporters), with the channel length directly influencing the producer's share of the final price. In major producing districts of Tamil Nadu such as Madurai and Dindigul, three distinct channels operate based on harvest time and quality: early morning harvests are directed to export markets, mid-day harvests to domestic wholesale and lower-grade harvests to essential oil extraction units (31, 52). Commission agents dominate price formation and over 76 % of the 120 jasmine growers surveyed in Thirumangalam and Thiruparankundram taluks of Madurai district, Tamil Nadu, sold exclusively through intermediaries, significantly reducing net farm returns (53).

Price volatility is a persistent challenge in jasmine markets, driven by the crop's extreme perishability, seasonal supply fluctuations and festival-driven demand spikes. Studies from Madurai, one of India's largest jasmine trading hubs, identified price instability and inadequate cold-chain infrastructure as the foremost constraints reported by marketers, with prices crashing dramatically during peak harvest seasons (10).

Role of women in post-harvest management

Women constitute the primary workforce in jasmine post-harvest operations (1), performing virtually all activities from pre-dawn harvesting and sorting to garland making and local market vending across producing regions of Tamil Nadu and Karnataka (1). In the Shankarpura mallige production system of coastal Karnataka, women's labour in harvesting and post-harvest processing has sustained a community-based jasmine enterprise across generations, with the variety's geographical indication (GI) recognition providing premium market access (54).

Export standards and quality certification

Export-grade jasmine flowers require a phytosanitary certificate under India's Plant Quarantine framework, declaring that the consignment meets the importing country's phytosanitary requirements. For European Union (EU) pesticide residues, since no jasmine-specific MRL exists, the general default maximum residue limit (MRL) of 0.01 mg/kg applies to any pesticide not specifically listed for that crop. Both requirements are enforced through Agricultural and Processed Food Products Export Development Authority (APEDA), which oversees floriculture export promotion and compliance (55, 56).

Post-harvest loss assessment and economic impact

Post-harvest losses in jasmine range from 15–35 % of gross production across producing regions of India and Southeast Asia, driven by the flower's compressed commercial lifespan of 24–48 hr under ambient conditions (29, 57). Rapid petal browning via polyphenol oxidase activity, volatilisation of fragrance compounds and moisture-driven wilting are the primary physiological mechanisms underlying these losses, all of which are substantially accelerated by delays in cold-chain management and rough handling during transport (58, 59). A socio-economic analysis of the Madurai jasmine market estimated that targeted improvements in packaging and cold-chain infrastructure alone could reduce losses by up to 20 %, yielding measurable gains across all supply chain stakeholders (10). Post-harvest

losses in jasmine supply chain and mitigation strategies are presented in Table 4.

Constraints and research gaps

Standardisation issues in modified atmospheric package and controlled atmospheric storage

Modified atmosphere and packaging studies on jasmine, though promising, remain fragmented with variations in film type and gauge (e.g., the 24 µm polypropylene film), ventilation, storage temperature and floral stage at packing, making it difficult to establish standardised protocols for producers and traders (8, 60).

Limited molecular studies on senescence control

Molecular-level understanding of senescence in jasmine flowers is considerably underdeveloped. The regulatory pathways governing petal senescence involving ethylene biosynthesis genes (ACS, ACO), NAC transcription factors and downstream senescence-associated genes (SAGs) have not been characterised in *Jasminum* species at the transcriptomic level. Jasmonic acid (JA) is emerging as a key player in the control of senescence, with the regulatory network of ethylene and JA involving integration of transcription factors, microRNAs and other hormones, yet no such network has been mapped specifically for jasmine petals. The absence of jasmine-specific genomic or proteomic data limits the development of targeted biotechnological interventions to delay post-harvest senescence (61–63).

Table 4. Post-harvest losses in jasmine supply chain and mitigation strategies

Loss type	Estimated loss range	Primary causes	Mitigation strategies	Strength of evidence	References
Physiological deterioration	15–35 % of production	Rapid petal browning (PPO activity), moisture loss, wilting, compressed 24–48 hr shelf life	Cold storage, chemical treatments (boric acid, sucrose, silver NPs), MAP packaging	Robust (multiple studies/species)	(10, 29, 57, 59)
Fragrance loss	Quality degradation	Volatilisation of key aroma compounds (α -farnesene, linalool, benzyl acetate)	Rapid pre-cooling, controlled temperature storage, timing harvest to peak emission window	Robust (multiple studies/species)	(25, 59, 78)
Cold chain failures	Contributes to 20–40 % total losses	Inadequate pre-cooling, transport delays, temperature fluctuations, broken cold chain	IoT sensor networks, blockchain traceability, gel-ice packing, improved infrastructure	Robust (multiple studies/species)	(10, 31, 41, 72)
Marketing and handling losses	Economic impact severe for small growers	Rough handling, lack of grading standards, high commission charges, price volatility	Systematic grading, cooperative marketing, real-time market intelligence, standardised protocols	Robust (multiple studies/species)	(10, 52, 79)
Export quality failures	Variable, quality-dependent	Insufficient freshness index, excessive browning, fragrance deterioration during 36 hr + transit	4 % boric acid + aluminium-lined boxes + gel ice; certification; pre-cooling protocols	Robust (multiple studies/species)	(31, 54)
Economic impact	Net profitability erosion	Post-harvest wastage, high commission (intermediaries), transport costs	Value addition (oil extraction, drying); improved cold chain can reduce losses by 20 %	Robust (multiple studies/species)	(10, 16, 18, 79)

IoT: Internet of Things; NPs: nanoparticles; MAP: modified atmosphere packaging; PPO: polyphenol oxidase.



Need for artificial intelligence-based grading and predictive modelling

Jasmine flower grading in India and other producing countries remains largely manual, subjective and labour-intensive, resulting in inconsistencies in quality assessment and market value. A novel algorithm for jasmine quality detection using colour, shape and texture features combined with support vector machine (SVM) and random forest classifiers achieved classification accuracies of 83.0 % and 56.7 % respectively, demonstrating the feasibility of automated grading (64); however, practical deployment at the farm or packhouse level remains unrealised. More recently, deep learning and quantum machine learning approaches using convolutional neural network (CNN) architectures have been proposed to assess jasmine freshness based on visual features such as colour, texture and structural integrity, though scalability and real-time deployment challenges persist (65). The absence of large, annotated jasmine-specific image datasets comprising several thousand to tens of thousands of labelled images, comparable to those used for similar flower and produce classification tasks and the lack of integration with Internet of Things (IoT)-based cold-chain monitoring systems represent major limitations for artificial intelligence (AI)-driven post-harvest decision support for jasmine (66).

Gaps in sustainable processing technologies

Conventional solvent-based extraction of jasmine concrete using hexane may leave residual solvent and hexane is classified as a Class 2 solvent with an ICH Q3C permitted daily exposure (PDE) of 2.9 mg/day (equivalent to a concentration limit of 290 ppm), posing environmental and occupational health risks, yet greener alternatives remain underexplored at industrial scale. Supercritical CO₂ extraction provides higher yields of jasmine oil, whereas MAE together with ultrasound-assisted extraction (UAE) shortens extraction duration and lowers energy consumption; subcritical water extraction completely avoids the use of organic solvents, though challenges such as high equipment costs, limited scalability and parameter process optimisation continue to be major challenges (67).

Future perspectives

Omics-based improvement of fragrance stability

High-quality chromosome-scale genome sequencing of *J. sambac* (487.45 Mb), which identified 53 terpene synthase (TPS) genes involved in floral scent biosynthesis (68), has revealed that terpene synthase (TPS) genes associated with flower fragrance are considerably amplified through tandem duplications, while gene clusters belonging to the SABATH and BAHD gene superfamilies regulate phenylpropanoid/benzenoid biosynthesis pathways critical to jasmine aroma (27). Recent complete telomere-to-telomere genome sequencing of multi-petal "Hutou" jasmine combined with metabolomic profiling has identified hub genes HTWRKY41, HTWRKY53 and

HTHSP90 as potential regulators of volatile metabolite production, as well as four structural genes (BEAT3, BSMT1, BPBT2 and BPBT3) that are involved in the biosynthesis and release of major volatile ester compounds (9). Future breeding programmes leveraging transcriptomic and metabolomic datasets can enable targeted enhancement of fragrance stability during post-harvest storage by overexpressing or editing biosynthetic genes controlling α -farnesene, benzyl acetate and linalool production, thereby extending the commercial value window of jasmine flowers (69).

Genetic and molecular approaches for delayed senescence

Genetic modification targeting ethylene biosynthesis genes such as ACC synthase (ACS) and ACC oxidase (ACO) or introducing mutated ethylene receptor genes like *etr1-1*, has successfully prolonged flower longevity in carnation, petunia and torenia by 3–9 days, demonstrating the feasibility of transgenic approaches to delay petal senescence. CRISPR/Cas9-mediated gene editing offers precise manipulation of key senescence regulators, including NAC transcription factors such as EPHEMERAL1 (EPH1) and autophagy genes like ATG6, which have been shown to significantly extend flower longevity in Japanese morning glory and petunia through targeted mutagenesis without introducing foreign DNA. For jasmine, genome editing of ethylene-responsive and jasmonate-signalling genes identified through RNA-seq analysis, combined with petal-specific promoters, represents a promising strategy to develop cultivars with extended shelf life while avoiding regulatory constraints associated with conventional transgenics (61,70).

Climate-resilient postharvest systems

Future postharvest systems must incorporate AI- and machine learning-based predictive modelling of temperature-quality relationships, climate-controlled microenvironments during transit and breed selection of jasmine genotypes exhibiting natural heat-shock protein (HSP) upregulation and antioxidant enzyme activity to ensure supply chain resilience under global warming scenarios (71).

Integration of advanced cold chain infrastructure

Implementation of smart cold chain infrastructure combining radio frequency identification (RFID) tags, global positioning system (GPS) tracking, multi-sensor arrays (temperature, ethylene, CO₂) and blockchain-anchored traceability for jasmine flowers can reduce postharvest losses by 30–70 %, enable rapid recall during quality excursions and build consumer trust through verifiable supply chain transparency. Although these technologies have been primarily developed and validated in food and general cold-chain supply systems rather than jasmine or floriculture, they offer promising approaches for improving traceability and quality management in the jasmine supply chain (72–74).



Circular bioeconomy and waste valorisation

Waste *J. sambac* flower biomass has demonstrated viability as a substrate for bioethanol production through boiling and autoclave pretreatment, followed by cellulase-mediated enzymatic hydrolysis, achieving an ethanol yield of 6.54 g/L (70). Floral waste valorisation aligns with sustainable development goals by converting ceremonial and postharvest jasmine waste into bioethanol, bioactive compounds and bio-based nanomaterials, reducing greenhouse gas emissions (75). Future biorefinery strategies should integrate supercritical CO₂ extraction of essential oils, recovery of polyphenolic antioxidants and dietary fibre, anaerobic digestion for biogas production and extraction of pigments from jasmine waste to maximise resource efficiency, minimise environmental impact and create economic value from previously discarded biomass (76, 77).

2. Conclusion

This review has comprehensively examined the post-harvest physiology, preservation technologies, value addition strategies and supply chain dynamics of jasmine (*Jasminum* spp.), where post-harvest losses of 15–35 % and value-addition returns of 5–10-fold underscore the scale of opportunity. The biochemical basis of flower senescence encompassing membrane deterioration, enzymatic browning, oxidative stress and volatile degradation underscores the urgency of targeted post-harvest interventions (58). Volatile biosynthesis follows distinct temporal patterns, with peak fragrance emission occurring 6–10 hr post-harvest via mevalonate (MVA)-mediated sesquiterpene production, methylerythritol phosphate (MEP) pathway monoterpenes and phenylpropanoid-derived benzenoids (25, 27).

Future research must prioritise standardisation of MAP protocols across species and cultivars, comprehensive toxicological assessment of chemical treatments and commercial-scale validation of Generally Recognised as Safe (GRAS)-status natural preservatives. Realising jasmine's full potential as a sustainable, high-value commodity demands integrated action: rapid technology adoption, investment in cold chain infrastructure, inclusive institutional support and capacity building across the value chain, particularly for smallholder women growers who remain central to jasmine cultivation and post-harvest management (57, 65). The convergence of traditional knowledge with modern science holds promises for securing jasmine's enduring role as the 'queen of fragrance' in global floriculture well into the 21st century.

Acknowledgements

The authors extend their gratitude to the library, peers, mentors and research facilities for providing access to relevant databases.

Authors' contributions

NA conceptualised the review, conducted the literature search and wrote the manuscript. TSP guided the preparation of the manuscript in the proper format and approved the final manuscript. KS contributed to developing ideas and reviewing the manuscript. VB provided additional support and contributed to the review. SN assisted with data collection and analysis as part of the research study. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest

Authors do not have any conflict of interests to declare.

Ethical issues

None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used Grammarly and Quill Bot solely for language editing and improving readability. The authors reviewed and approved the final manuscript and take full responsibility for the content of publication.

References

1. Barad A, Gandamalla M, Maheta P. Role of rural women in post-harvest handling and export of jasmine flower. *Universal Journal of Agricultural Research*. 2017;5(6):329–32. <http://doi.org/10.13189/ujar.2017.050602>
2. Paibon W, Yimnoi CA, Tembab N, Boonlue W, Jampachaisri K, Nuengchamnon N, et al. Comparison and evaluation of volatile oils from three different extraction methods for some Thai fragrant flowers. *International Journal of Cosmetic Science*. 2011;33(2):150–6.
3. Weber A, Kubitzki K, Kadereit J. The families and genera of vascular plants. *Flowering plants: Dicotyledons; Lamiales (except Acanthaceae including Avicenniaceae)*. 2004;7:63–158. <http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:328128-2>
4. Royal Botanic Gardens K. Plants of the World Online (POWO): *Jasminum*. 2025.
5. Manimaran P, Ganga M, Kannan M, Arulmozhiselvan K. Standardization of postharvest management techniques for *Jasminum nitidum* flowers. *Chemical Science Review and Letters*. 2018;7(26):652–8.
6. Nisha VS, Parasuraman B, Kannan M. Petals to profit: value chain analysis of jasmine and tuberose in Tamil Nadu. *Madras Agricultural Journal*. 2025;112(4):28–35.
7. Simamora L, Zebua DDN, Handoko YA, Suprihati S. Analysis of competitiveness and government policies on



- Indonesian white jasmine (*Jasminum sambac*) farming. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian*. 2023;7(1):212–22. <http://doi.org/10.14710/agrisocionomics.v7i1.15580>
8. Varpe K, Shirke G, Pujari K. Effect of post harvest chemical treatment on the post harvest life of jasmine (*Jasminum sambac* L. Aiton) flowers. *International Journal of Current Microbiology and Applied Sciences*. 2020;9(8):502–8. <http://doi.org/10.20546/ijcmas.2020.908.057>
 9. Chen G, Mostafa S, Lu Z, Du R, Cui J, Wang Y, et al. The jasmine (*Jasminum sambac*) genome provides insight into the biosynthesis of flower fragrances and jasmonates. *Genomics, Proteomics & Bioinformatics*. 2023;21(1):127–49. <http://doi.org/10.1016/j.gpb.2022.12.005>
 10. Nirmala L, Brindha I. Global perspectives on socio-economic dynamics, marketing practices and challenges in jasmine trade: evidence from a prominent Indian flower market. 2025. <http://doi.org/10.14719/pst.6262>
 11. Praveen D, Ramachandran A. Development of regional crop simulation modeling for jasmine under the purview of climate change: a perspective from Tamil Nadu, India. *Horticulture International Journal*. 2017;1(2):49–51. <http://doi.org/10.15406/hij.2017.01.00009>
 12. Yeamsuriyotai K, Pradabkun N, Manichart N, Yonsawad N, Khamchatra N-m, Laosinwattana C, et al. Formulation and evaluation of nanoemulsions from *Jasminum officinale* essential oil for controlling postharvest browning and maintaining quality in jasmine (*Jasminum sambac*) flowers. *Frontiers in Plant Science*. 2025;16:1541721. <http://doi.org/10.3389/fpls.2025.1541721>
 13. Ali SM, Nidoni U, Palanimuthu SH, Ramappa K, Ramesh G, Naik N. Enhancing shelf life and freshness retention in jasmine flowers (*Jasminum multiflorum* L.) through post-harvest chemical treatments. *International Journal of Advanced Biochemistry Research*. 2024;8:265–70. <http://doi.org/10.33545/26174693.2024.v8.i3Sd.720>
 14. Tazeen H, Joice A, Tufaique T, Igathinathane C, Ajayi-Banji A, Zhang Z, et al. Jasmine flower color degradation user-coded computer vision image analysis tool and kinetics modeling. *AgriEngineering*. 2025;7(6):193. <http://doi.org/10.3390/agriengineering7060193>
 15. Issa MY, Mohsen E, Younis IY, Nofal ES, Farag MA. Volatiles distribution in jasmine flowers taxa grown in Egypt and its commercial products as analyzed via solid-phase microextraction (SPME) coupled to chemometrics. *Industrial Crops and Products*. 2020;144:112002. <http://doi.org/10.1016/j.indcrop.2019.112002>
 16. Choudhary S, Das JN, Mohanty CR, Das AK, Mishra A. Packaging technology for extending shelf-life of jasmine (*Jasminum sambac* cv. Gundumulli) flowers. *International Journal of Current Microbiology and Applied Sciences*. 2019;8(9):1724–32. <http://doi.org/10.20546/ijcmas.2019.809.199>
 17. Ranchana P, Ganga M, Jawaharlal M, Kannan M. Analysis of volatile compounds of *Jasminum nitidum* [Acc. JN. 1] flowers. *International Journal of Current Microbiology and Applied Sciences*. 2017;6:5411–8. <http://doi.org/10.20546/ijcmas.2017.611.517>
 18. Ffadhilah A, Chitra R, Ganga M, Prasanthrajan M, Djanaguiraman M. Chitosan-based biodegradable packaging: enhancing the shelf life and quality of *Jasminum sambac* L. flowers. *Plant Science Today*. 2024;11:5438. <http://doi.org/10.14719/pst.5438>
 19. Karuppaiah P, Kumar SR, Rajkumar M. Effect of different packages on the post harvest behaviour and shelf life of jasmine (*Jasminum sambac*). 2006.
 20. Nirmala Srinivas NS, Reddy T. Shelf life of jasmine (*Jasminum sambac*) flowers as influenced by packaging and ventilation. 1993.
 21. Singh A, Dhaduk B, Ahlawat T, editors. Storage of jasmine (*Jasminum sambac*) in passive MAP. IX International Symposium on Postharvest Quality of Ornamental Plants. 2008;847. <http://doi.org/10.17660/ActaHortic.2009.847.43>
 22. Lavanya V, Nidoni U, Kisan B, Amarananjundeshwara H, Ramya V. Physiological characterization of jasmine flower (*Jasminum sambac*) senescence during storage. *Journal of Applied & Natural Science*. 2016;8(3). <http://doi.org/10.31018/jans.v8i3.986>
 23. Janani PB, Premavathi R, Sasikala R. Marketing behaviour of jasmine growers. *Journal of Extension Education*. 2016;28(4).
 24. Jawaharlal M, Thamaraiselvi S, Ganga M. Packaging technology for export of jasmine (*Jasminum sambac* Ait.) flowers. *Journal of Horticultural Sciences*. 2012;7(2):180–9.
 25. Yu Y, Lyu S, Chen D, Lin Y, Chen J, Chen G, et al. Volatiles emitted at different flowering stages of *Jasminum sambac* and expression of genes related to α -farnesene biosynthesis. *Molecules*. 2017;22(4):546.
 26. Zhou C, Zhu C, Tian C, Xu K, Huang L, Shi B, et al. Integrated volatile metabolome, multi-flux full-length sequencing and transcriptome analyses provide insights into the aroma formation of postharvest jasmine (*Jasminum sambac*) during flowering. *Postharvest Biology and Technology*. 2022;183:111726. <http://doi.org/10.1016/j.postharvbio.2021.111726>
 27. Fang J, Zhou L, Chen Q, Wang J, Zhuang Y, Lin S, et al. Integrated multi-omics analysis unravels the floral scent characteristics and regulation in “Hutou” multi-petal jasmine. *Communications Biology*. 2025;8(1):256. <http://doi.org/10.1038/s42003-025-07685-w>
 28. Mohanasundari P, Sivakumar T, Krishna Surendar K. Effect of post-harvest treatment and storage temperature on fragrance of jasmine (*J. grandiflorum*). *Annals of Plant Sciences*. 2018;7:2391–3. <http://doi.org/10.21746/aps.2018.7.8.4>
 29. Sanchez F Jr, Mojica L, Penamante-Khe C. Post-harvest handling practices and marketing system of jasmine (*Jasminum sambac*) [L.] Aiton in the Philippines. 2011.
 30. Nowak J, Rudnicki RM, Duncan AA. Postharvest handling and storage of cut flowers, florist greens and potted plants. 1990. <http://doi.org/10.1007/978-94-009-0425-5>
 31. Jawaharlal M, Thamaraiselvi S, Ganga M, editors. Standardization of export packaging technology for jasmine (*Jasminum sambac* Ait.) flowers. *International Conference on Quality Management in Supply Chains of Ornamentals QMSCO2012*. 2012;970. <http://doi.org/10.17660/ActaHortic.2013.970.8>
 32. Mohanasundari P, Sivakumar T, Surendar KK, Ganga M. Prolonging the shelf life of jasmine (*Jasminum grandiflorum*) buds by chemical treatments under cold storage condition. *Journal of Agriculture and Ecology*. 2018;6:85–93. <http://doi.org/10.53911/JAE.2018.6211>
 33. Musyoki MS, Kihara A. Cold chain infrastructure management strategies and performance of flower industry in Kenya. *Journal of Business and Strategic Management*. 2025;10(8):1–19. <http://doi.org/10.47941/jbsm.2784>

34. Devi MP, Chakrabarty S, Ghosh S, Bhowmick N. Essential oil: its economic aspect, extraction, importance, uses, hazards and quality. In: Value addition of horticultural crops: recent trends and future directions. 2015. p.269–78. http://doi.org/10.1007/978-81-322-2262-0_15
35. Stratakis AC, Koidis A. Methods for extracting essential oils. In: Essential oils in food preservation, flavor and safety. 2016. p.31–8. <http://doi.org/10.1016/B978-0-12-416641-7.00004-3>
36. Kant R, Kumar A. Review on essential oil extraction from aromatic and medicinal plants: techniques, performance and economic analysis. Sustainable Chemistry and Pharmacy. 2022;30:100829. <http://doi.org/10.1016/j.scp.2022.100829>
37. Katekar VP, Rao AB, Sardeshpande VR. A hydrodistillation-based essential oils extraction: a quest for the most effective and cleaner technology. Sustainable Chemistry and Pharmacy. 2023;36:101270. <http://doi.org/10.1016/j.scp.2023.101270>
38. Machado CA, Oliveira FO, de Andrade MA, Hodel KVS, Lepikson H, Machado BAS. Steam distillation for essential oil extraction: an evaluation of technological advances based on an analysis of patent documents. Sustainability. 2022;14(12):7119. <http://doi.org/10.3390/su14127119>
39. Zhou W, Li J, Wang X, Liu L, Li Y, Song R, et al. Research progress on extraction, separation and purification methods of plant essential oils. Separations. 2023;10(12):596. <http://doi.org/10.3390/separations10120596>
40. Sareriya K, Vanzara P, Upadhyay D. Methodology for extraction of essential oils: a review. International Journal for Multidisciplinary Research. 2023;5(4). <http://doi.org/10.36948/ijfmr.2023.v05i04.5442>
41. Younis A, Mehdi A, Riaz A. Supercritical carbon dioxide extraction and gas chromatography analysis of *Jasminum sambac* essential oil. Pakistan Journal of Botany. 2011;43:163–8.
42. Abera WA, Kassahun SK, Beyene AM, Mohammed SA. Statistical optimization for comparative study of microwave and ultrasonic-assisted extraction techniques for phenolic compounds recovery from jasmine leaf extracts. Biomass Conversion and Biorefinery. 2025;15(10):15957–74. <http://doi.org/10.1007/s13399-024-06372-w>
43. Vinatoru M, Mason T, Calinescu I. Ultrasonically assisted extraction (UAE) and microwave assisted extraction (MAE) of functional compounds from plant materials. TrAC Trends in Analytical Chemistry. 2017;97:159–78. <http://doi.org/10.1016/j.trac.2017.09.002>
44. Jin Y, Hu D, Chen Q, Shi C, Ye J, Dai Z, et al. Water-based green and sustainable extraction protocols for value-added compounds from natural resources. Current Opinion in Green and Sustainable Chemistry. 2023;40:100757. <http://doi.org/10.1016/j.cogsc.2023.100757>
45. Barman M, Soren M, Mishra C, Mitra A. Dehydrated jasmine flowers obtained through natural convective solar drying retain scent volatiles and phenolics—a prospective for added-value utility. Industrial Crops and Products. 2022;177:114483. <http://doi.org/10.1016/j.indcrop.2021.114483>
46. Prakash O, Sahoo D, Rout PK. Liquid CO₂ extraction of *Jasminum grandiflorum* and comparison with conventional processes. Natural Product Communications. 2012;7(1):1934578X1200700131. <http://doi.org/10.1177/1934578X1200700131>
47. Wu L-C, Lin C-L, Peng C-C, Huang T-L, Tsai T-H, Kuan Y-E, et al. Development from *Jasminum sambac* flower extracts of products with floral fragrance and multiple physiological activities. Evidence-Based Complementary and Alternative Medicine. 2021;2021(1):7657628. <http://doi.org/10.1155/2021/7657628>
48. Dinh Phuc N, Phuong Thy LH, Duc Lam T, Yen VH, Thi Ngoc Lan N, editors. Extraction of jasmine essential oil by hydrodistillation method and applications on formulation of natural facial cleansers. IOP Conference Series: Materials Science and Engineering. 2019;542(1):012057. <http://doi.org/10.1088/1757-899X/542/1/012057>
49. Ranchana P, Ganga M, Jawaharlal M, Kannan M. Analysis of volatile compounds from the concrete of *Jasminum multiflorum* flowers. International Journal of Current Microbiology and Applied Sciences. 2017;6:2229–33. <http://doi.org/10.20546/ijcmas.2017.611.264>
50. Akram A, Younis A, Akhtar G, Ameer K, Farooq A, Hanif MA, et al. Comparative efficacy of various essential oil extraction techniques on oil yield and quality of *Jasminum sambac* L. Science International. 2017;5(3):84–95. <http://doi.org/10.17311/sciintl.2017.84.95>
51. Chen Hy, Ying Jq, An Hm, Chen Y, Huang Yw, Jiang Yc, et al. Chinese jasmine tea: the harmonious intertwining of tea and jasmine fragrance. Comprehensive Reviews in Food Science and Food Safety. 2025;24(4). <http://doi.org/10.1111/1541-4337.70210>
52. Manivenkatesh K, Selvanayagi S, Devi MN, Pandiyan M. Value chain analysis of jasmine in Madurai district of Tamil Nadu. International Journal of Farm Sciences. 2020;10(1):6–12. <http://doi.org/10.5958/2250-0499.2020.00002.6>
53. Thulasiram R, Sivaraj P. An economic analysis of production and marketing of jasmine in Madurai District of Tamil Nadu. International Journal of Farm Sciences. 2020;10(2):60–7. <http://doi.org/10.5958/2250-0499.2020.00035.X>
54. Handy F, Cnaan RA, Bhat G, Meijs LC. Jasmine growers of coastal Karnataka: grassroots sustainable community-based enterprise in India. Entrepreneurship & Regional Development. 2011;23(5-6):405–17. <http://doi.org/10.1080/08985626.2011.580166>
55. Shaikh S, Oza H, Solanki H. Biopesticides utilization scenario in India: recent trends in biopesticides implemented strategies for sustainable horticulture. SARPS: Journal of Advanced Research in Plant Science. 2026;2(1):1–21. <http://doi.org/10.29121/SARPS.v1.i1.2025.18>
56. Gupta S, Verma S, Thakur R. Phytosanitary requirement for import of horticulture crops. International Journal of Current Microbiology and Applied Sciences. 2019;8(2):2871–86. <http://doi.org/10.20546/ijcmas.2019.802.337>
57. Tejasri N. Supply chain analysis of jasmine in Guntur District of Andhra Pradesh [master's thesis]. Acharya NG Ranga Agricultural University; 2021.
58. Marappan K, Khanchana K, Arumugam V. Extending the shelf life and quality of jasmine (*Jasminum sambac*) through different chemical treatments. Research Journal of Agricultural Sciences. 2024;15(3):656–60.
59. Nurila I, Falah M, editors. Maintaining the physical quality of jasmine flowers (*Jasminum sambac*) during its storage using low temperature treatments. II International Symposium on Tropical and Subtropical Ornamentals. 2021;1334. <http://doi.org/10.17660/ActaHortic.2022.1334.42>

60. Rashed NM, Memon SA, Turki SMA, Shalaby TA, El-Mogy MM. An analysis of conventional and modern packaging approaches for cut flowers: a review article. *Frontiers in Plant Science*. 2024;15:1371100. <http://doi.org/10.3389/fpls.2024.1371100>
61. Shibuya K. Molecular aspects of flower senescence and strategies to improve flower longevity. *Breeding Science*. 2018;68(1):99–108. <http://doi.org/10.1270/jsbbs.17081>
62. Sun X, Qin M, Yu Q, Huang Z, Xiao Y, Li Y, et al. Molecular understanding of postharvest flower opening and senescence. *Molecular Horticulture*. 2021;1(1):7. <http://doi.org/10.1186/s43897-021-00015-8>
63. van Doorn WG, Woltering EJ. Physiology and molecular biology of petal senescence. *Journal of Experimental Botany*. 2008;59(3):453–80. <http://doi.org/10.1093/jxb/erm356>
64. Krishnaveni S, Pethalakshmi A. Toward automatic quality detection of *Jasmenum* flower. *ICT Express*. 2017;3(3):148–53. <http://doi.org/10.1016/j.ict.2017.04.006>
65. Cauvery KP, Thrisha R, Harshitha T, Panigrahi S, Thangavel SK, Somasundaram K, et al. A grading model for jasmine flowers using deep learning and quantum machine learning. 4th International Conference on Sentiment Analysis and Deep Learning (ICSADL). 2025. IEEE.
66. KV D, Vaibhavi K, Aditi S, Tejaswini M. Flower identification and quality assessment using ML and CNN. *Grenze International Journal of Engineering & Technology (GIJET)*. 2024;10.
67. Ali SM, Nidoni UK. Optimizing jasmine flower extraction: a review of modern approaches. *Archives of Current Research International*. 2025;25(3):42–51. <http://doi.org/10.9734/acri/2025/v25i31095>
68. Bera P, Kotamreddy JNR, Samanta T, Maiti S, Mitra A. Inter-specific variation in headspace scent volatiles composition of four commercially cultivated jasmine flowers. *Natural Product Research*. 2015;29(14):1328–35. <http://doi.org/10.1080/14786419.2014.1000319>
69. Qi X, Wang H, Chen S, Feng J, Chen H, Qin Z, et al. The genome of single-petal jasmine (*Jasminum sambac*) provides insights into heat stress tolerance and aroma compound biosynthesis. *Frontiers in Plant Science*. 2022;13:1045194. <http://doi.org/10.3389/fpls.2022.1045194>
70. Raheena K, Uthup TK, Athira P, Prabhakaran D, Vinod A, Rekha K. Manipulation of floral senescence through gene editing: prospects for ornamental and cut flowers. *Plant Growth Regulation*. 2025;1–16. <http://doi.org/10.1007/s10725-025-01391-7>
71. Li N, Euring D, Cha JY, Lin Z, Lu M, Huang L-J, et al. Plant hormone-mediated regulation of heat tolerance in response to global climate change. *Frontiers in Plant Science*. 2021;11:627969. <http://doi.org/10.3389/fpls.2020.627969>
72. Duman E, Aydoğan E. Enhancing traceability and reliability in cold chain logistics through Hyperledger Fabric and IoT. *Applied Sciences*. 2025;15(22):12149. <http://doi.org/10.3390/app152212149>
73. Tsang YP, Choy KL, Wu CH, Ho GTS, Lam HY. Blockchain-driven IoT for food traceability with an integrated consensus mechanism. *IEEE Access*. 2019;7:129000–17. <http://doi.org/10.1109/ACCESS.2019.2940227>
74. Gillespie J, da Costa TP, Cama-Moncunill X, Cadden T, Condell J, Cowderoy T, et al. Real-time anomaly detection in cold chain transportation using IoT technology. *Sustainability*. 2023;15(3):2255. <http://doi.org/10.3390/su15032255>
75. Khammee P, Unpaprom Y, Chaichompoo C, Khonkaen P, Ramaraj R. Appropriateness of waste jasmine flower for bioethanol conversion with enzymatic hydrolysis: sustainable development on green fuel production. *3 Biotech*. 2021;11(5):216. <http://doi.org/10.1007/s13205-021-02776-x>
76. Gupta VK, Kumar R, Dhanker R, Kamble SS, Mohamed HI. Sustainable management of floral waste to reduce environmental pollution by conversion to value-added products and their applications in the synthesizing of nanomaterials: a review. *Water, Air, & Soil Pollution*. 2024;235(7):436. <http://doi.org/10.1007/s11270-024-07228-9>
77. Kumar H, Guleria S, Dhalaria R, Kimta N, Sethi N, Dhanjal DS, et al. Valorization of flowers and their role in circular bioeconomy and sustainable development goals. *Bioresources and Bioprocessing*. 2025;12(1):1–21. <http://doi.org/10.1186/s40643-025-00954-w>
78. Balkrishna A, Rohela A, Kumar A, Kumar A, Arya V, Thakur P, et al. Mechanistic insight into antimicrobial and antioxidant potential of *Jasminum* species: a herbal approach for disease management. *Plants*. 2021;10(6):1089. <http://doi.org/10.3390/plants10061089>
79. Thangamayan S, Sugumar S, Chandrachud S. An economic analysis of jasmine cultivation in Madurai District, Tamil Nadu. *Indian Journal of Public Health Research & Development*. 2019;10(4). <http://doi.org/10.5958/0976-5506.2019.00711.3>
80. ThamaraiSelvi SP. Standardization of export packaging technology for jasmine (*Jasminum* spp.) and tuberose (*Polianthes tuberosa* L.). [PhD thesis]. Coimbatore: Tamil Nadu Agricultural University; 2009.

Additional information

Peer review: Publisher thanks the Sectional Editor and anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information: Available at https://horizonpublishing.com/journals/index.php/PST/open_access_policy.

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: See https://horizonpublishing.com/journals/index.php/PST/indexing_abstracting.

Copyright: © The Author(s). This is an open-access article distributed under the Creative Commons Attribution License CC BY 4.0.

Publisher information: Plant Science Today is published by Horizon e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.

