



LITCHI

COLD CHAIN GUIDELINES

JUNE 2025

United Nations Environment Programme (UNEP) Cool Coalition in partnership with the Alliance for an Energy Efficient Economy (AEEE), is implementing the project “Scaling-up Investment in Clean and Efficient Cold chain in India.” The project aims to accelerate the development of sustainable and integrated cold chain in India and selected states. It is supporting the national government and two states, namely Bihar and Haryana, in mainstreaming energy-efficient, renewable energy-powered, and low-GWP refrigerant cold chain infrastructure and services in rural areas, particularly focusing on packhouses and reefer transport as part of an integrated cold-chain. The project is contributing to the implementation of India’s Cooling Action Plan and is working to enhance rural livelihoods.

The Cool Coalition is a global multi-stakeholder network that connects a wide range of key actors from government, cities, international organizations, businesses, finance, academia, and civil society groups to facilitate knowledge exchange, advocacy and joint action towards a rapid global transition to efficient and climate-friendly cooling.

Alliance for an Energy Efficient Economy (AEEE) supports policy implementation and enables the energy efficiency market with a not-for-profit motive. AEEE promotes energy efficiency as a resource and collaborates with industry and government to transform the market for energy-efficient products and services, thereby contributing toward meeting India’s goals on energy security, clean energy, and climate change.

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01

INTRODUCTION

Litchi, a highly perishable fruit, holds significant economic importance in Bihar, where it is extensively cultivated and contributes to the livelihood of many farmers. The rapid deterioration of litchi due to its high moisture content and susceptibility to browning poses challenges in maintaining its marketability. Effective post-harvest management and robust cold chain practices are crucial in extending the fruit's shelf life, preserving its nutritional value, and maintaining its market appeal. This document provides comprehensive guidelines to optimize the litchi cold chain in Bihar, focusing on best practices to maintain the fruit's quality throughout its journey from farm to market.

United Nations Environment Programme (UNEP) Cool Coalition in partnership with the Alliance for an Energy Efficient Economy (AEEE) are providing technical assistance to Bihar's Department of Agriculture under the India Cold-Chain Programme (ICCP). Through its Directorate of Horticulture, the Department has recommended developing specific cold chain guidelines for litchi in Bihar. This document aims to provide these guidelines, tailored to the state's needs and can be shared with the Department of Horticulture, the Department of Industry, and Farmer's Producer Companies (FPCs) to benefit smallholder farmers, cold chain operators, and other stakeholders involved in the litchi value chains.

Effective post-harvest management is crucial for preserving the quality and extending the holding life and shelf life of litchi, a key horticultural crop in Bihar. The following points outline the primary challenges faced in the post-harvest management of litchi in the state.



Short Shelf Life: Litchi is a highly perishable fruit with a short shelf life of just 2-3 days at ambient temperatures, making rapid post-harvest handling and cooling essential.



Poor Cold-chain Logistics: Inefficient cold-chain system is seen from the lack of first-mile modern packhouse linked with refrigerated transport options, causing significant losses in the supply chain from farms to markets. Any improper handling and exposure to high temperatures accelerate spoilage in litchi.



Limited Access to Technology and Training: Farmers often have limited access to modern post-harvest and cold chain technologies and lack training on best practices for harvesting, preconditioning, pre-cooling, and handling litchi, leading to higher post-harvest losses.



Unpredictable Weather Conditions: Sudden weather changes, such as heatwaves or unseasonal rains, can adversely affect the quality of pre-harvest and harvested litchi, increasing the risk of spoilage.



High Post-Harvest Losses: Due to inadequate post-harvest management and integrated cold chain infrastructure, litchi in Bihar suffers from substantial post-harvest losses, directly affecting the economic returns for farmers.

To address these challenges effectively, it is crucial to establish appropriate post-harvest and cold-chain infrastructure and efficient systems. Ensuring that adequate and interlinked cold chain infrastructure and refrigerated transport options are in place will help mitigate spoilage and extend the holding and shelf life of litchi. Additionally, farmers need to understand and implement proper post-harvest management practices at the first-mile through proper preconditioning, pre-cooling and transport. Education and training on best practices for handling, aggregating, cooling, storing, and transporting litchi should be provided at both individual and group levels. Collective action among farmers is also essential to make post-harvest activities economically viable and to enhance the overall efficiency of the cold supply chain. This document aims to educate farmers (FPO/FPC), packhouse operators, and cold chain owners about cold chain activities for litchi, ultimately improving market linkage and enhancing value realization of the produce.

02

LITCHI PRODUCTION IN BIHAR

Bihar is renowned across country for its litchi production. During the litchi season, Bihar's produce is prominently featured in major markets throughout the country. As per the Ministry of Agriculture and Farmers' Welfare's Second Advanced Estimate for 2022-23, Bihar stands as the nation's leading litchi producer, contributing a substantial 41.5% of the total national production. (Ministry of Agriculture & Farmers' Welfare, 2023)

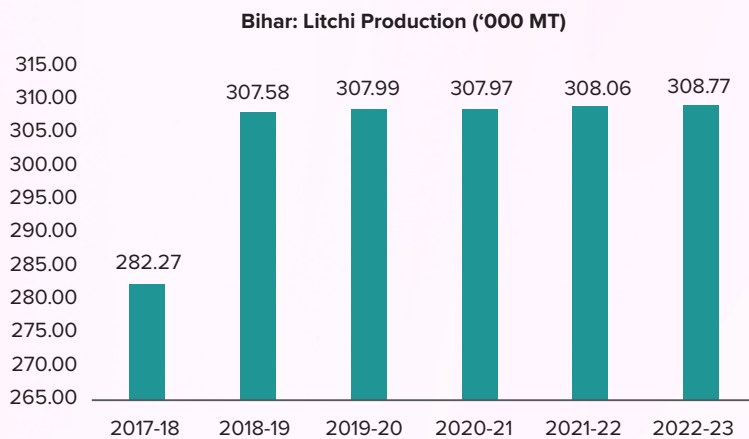


Figure 1: Bihar: Litchi production

Source: MoA&FW

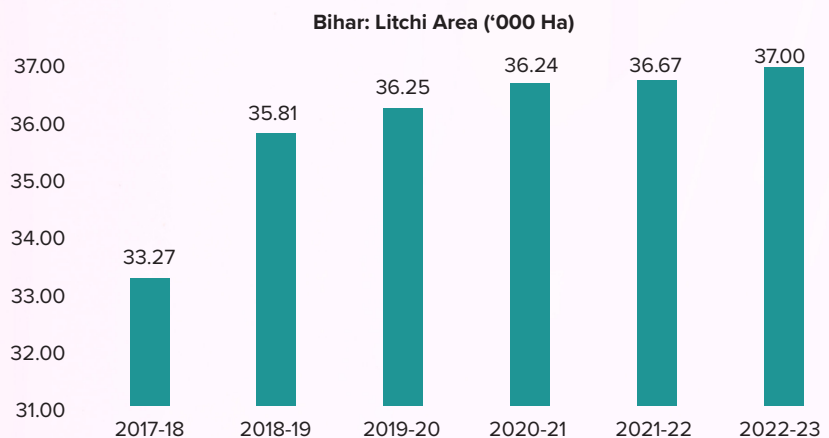


Figure 2: Bihar: Litchi Area

Source: MoA&FW

Table 1: District Wise Litchi Area & Production in Bihar

Districts	2022-23		2021-22		2020-21	
	Area ('000 Hectare)	Production ('000 Tonnes)	Area ('000 Hectare)	Production ('000 Tonnes)	Area ('000 Hectare)	Production ('000 Tonnes)
Muzaffarpur	11.67	147.95	11.67	147.95	11.19	147.75
E. Champaran	3.62	22.53	3.60	22.52	3.60	22.52
Vaishali	3.87	22.21	3.84	22.15	3.84	22.15
Sitamarhi	2.36	17.69	2.33	17.51	2.33	17.51
W. Champaran	2.25	12.01	2.24	11.98	2.22	12.07
Samastipur	1.56	10.83	1.55	10.80	1.54	10.50
Saran	1.14	9.06	1.13	9.04	1.13	9.04
Siwan	1.24	8.70	1.23	8.69	1.23	8.69
Purnea	1.32	8.52	1.32	8.46	1.32	8.46
Gopalganj	1.03	8.45	1.01	8.43	1.01	8.43
Sheohar	1.06	7.05	1.05	7.02	1.05	7.02
Saharsa	0.64	4.83	0.63	4.81	0.63	4.81
Darbhanga	0.87	4.24	0.85	4.23	0.92	4.43
Madhubani	0.77	4.23	0.75	4.21	0.75	4.21
Bhagalpur	0.63	4.14	0.62	4.13	0.62	4.13
Begusarai	0.53	2.92	0.52	2.90	0.52	2.90
Khagaria	0.33	2.26	0.32	2.24	0.32	2.24
Kishanganj	0.41	2.05	0.40	2.03	0.40	2.03
Munger	0.32	1.76	0.30	1.72	0.33	1.87
Katihar	0.24	1.53	0.23	1.51	0.23	1.51
Araria	0.45	1.51	0.43	1.49	0.43	1.48
Madhepura	0.24	1.49	0.24	1.47	0.24	1.47
Jamui	0.13	1.25	0.12	1.24	0.12	1.24
Supaul	0.16	0.92	0.15	0.89	0.15	0.89
Lakhisarai	0.08	0.40	0.08	0.39	0.08	0.39
Banka	0.11	0.23	0.10	0.30	0.10	0.30
Bihar	37.00	308.77	36.67	308.06	36.24	307.97

Area – '000 Hectare, Production – '000 Tonnes, Source – Economic Survey, 2023-24

Table 2: Export of Fresh Litchi from India In Terms of Quantity and their Corresponding Values

Country	2020-21		2021-22		2022-23	
	Qty	Rs. Lacs	Qty	Rs. Lacs	Qty	Rs. Lacs
Nepal	516.09	199.72	184.21	62.66	88.28	33.99
Bhutan	39.54	33.70	2.01	1.60	0.00	0.00
U Arab Emts	6.46	8.69	5.03	7.84	0.99	0.73
U K	3.84	13.31	0.96	3.75	0.00	0.00
Baharain Is	1.03	1.67	0.00	0.00	0.00	0.00
Qatar	0.84	0.60	0.82	1.11	0.55	1.21
Kuwait	0.03	0.04	0.15	0.28	0.00	0.00
Maldives	0.02	0.04	0.55	0.20	0.19	0.07
Oman	0.02	0.02	0.11	0.01	0.00	0.00
Total	567.89	257.80	193.85	77.46	90.01	36.00

Note: Value in Rs. Lacs, Qty in MT, Source – APEDA agriexchange

The districts of Muzaffarpur, Vaishali, Samastipur, Champaran, Begusarai, and surrounding areas in Bihar have a favorable climate for litchi cultivation. However, challenges remain, particularly regarding the short shelf life of fresh litchi, which lasts only two days after harvesting. This situation necessitates not only rapid pre-cooling immediately after harvest to remove field heat and slow down the fruit’s metabolic activity, but also proper short-term storing in cold rooms, rapid refrigerated transport to maintain the optimal temperature, humidity, and hygiene during transit. Unfortunately, the current infrastructure is inadequate to support such rapid pre-cooling and refrigerated transport requirements, limiting the potential for litchi reaching better paying domestic markets and export markets. Despite the implementation of fragmented cold chain technology, its effectiveness has been constrained by inadequate first-mile cold-chain infrastructure (packhouse/reefer), limiting supply to domestic consumption centers and exports primarily to West Asian countries. Addressing these essential infrastructure gaps is crucial to expanding the export potential of fresh litchis. (Harsh Kumar, 2024)

APEDA has played a pivotal role in enhancing the export of litchis from India. Collaborating with both the central and state governments, the organization has focused on establishing essential infrastructure, fostering market connections, implementing quality and phytosanitary checks and certifications, facilitating the establishment of packhouses, and monitoring pest surveillance. These efforts have paved the way for the smooth shipment of litchi consignments from India. With APEDA’s support, Bihar successfully sent its inaugural consignment of Shahi Litchis to the UK. This Geographical Indication (GI)-certified product is sourced from Muzaffarpur farmers by M/s. Cira Enterprises, was imported by H & J Veg of London. However, to fully realize this potential, further development of export infrastructure is essential. (April-June 2023, Apex Update, APEDA)





03

HARVESTING OF LITCHI

This section and Section 4 are based on existing guidelines and resources for litchi post-harvest management from reputable sources. The key documents referenced are:

- Global AgriSystem Private Limited, *Development of Potential Value Chain, Litchi, Study of Gaps in Infrastructure & Processing Facilities in Identified Clusters*
- Horticulture Mission for North East and Himalayan States, *Post-Harvest Handling and Storage*
- FAO, *Lychee Production in India*.
- ICAR - National Research Centre on Litchi, *Fruit Maturity and Harvest*
- ICAR - National Research Centre on Litchi, *Good Management Practices in Litchi*
- Rajendra Agricultural University, *Litchi, Production Technology and Post-harvest Handling for Export*.

The following sections briefly highlight key aspects of the above documents. Readers are encouraged to refer to these documents for more detailed information.

3.1 Maturity Indices

Litchi, a non-climacteric fruit, should be harvested at full maturity when the pericarp, seed, and aril are well-developed and the seed turns from green to brown. Immaturely harvested fruit tends to shrivel and soften without developing proper flavor, leading to rejection in the marketplace or fetching very low prices. Maturity indicators include declining acidity, increasing Total Soluble Solids (TSS), and characteristic color changes, with red pigmentation associated with anthocyanin pigments. The appearance and color of the fruit, particularly pericarp color and smoothness, are crucial criteria for harvesting. The fruit's color changes from green to pink upon reaching maturity. Harvesting time varies, taking 65-80 days from fruit set, depending on the cultivar.

In Bihar, maturation extends from the third to the fourth week of May and persists until the first week of June. (ICAR - National Research Centre on Litchi, 2001)

3.2 Harvesting

The objective of harvesting is to gather the crop without damage and deliver it to the market in optimal condition. Litchi's are harvested in clusters, including a section of the branch and a few leaves. This approach improves the fruits' shelf life while also providing a mild pruning effect to the tree. Harvesting focuses on selecting bunches at optimal maturity, determined by colour and pulp taste.

For local markets, fruits should be harvested at full ripeness. For distant markets, fruits should be picked when they have started turning reddish. For distant markets, harvesting is timed when TSS reaches 19° Brix, and acidity is 0.3 to 0.4 percent. (H.P. Singh and S. Babita). Harvesting should be scheduled for early morning or late afternoon to preserve fruit quality by maintaining water content and minimizing the risk of desiccation. The harvesting of the crop in Bihar starts towards the end of April, picks up during the 2nd /3rd week of May, and ends around the 1st week of June. (ICAR-National Research Centre on Litchi, 2011)

POST-HARVEST MANAGEMENT OF LITCHI

4.1 Activities at the Packhouse

Various activities are conducted in the packhouse to ensure that harvested litchis are prepared for eventual sale while maintaining their quality. The key activities include Receiving, Sorting and Grading, Washing and Cleaning, Fumigation, Packaging and Labeling, Pre-cooling, and Storage before being transported to markets.



Figure 3: Process flow at Litchi Packhouse for Local Markets



Figure 4: Process flow at Litchi Packhouse for Distant Domestic Premium/ Export Markets

a. Receipt and Unloading

Prompt unloading of litchi is crucial to minimize exposure to ambient temperatures, which can accelerate dehydration and browning of the pericarp (skin). Upon arrival at the packhouse facility, litchis should be unloaded immediately to prevent heat buildup and moisture loss. Care must be taken to avoid overstacking loose litchi clusters, as excessive weight can cause compression damage, leading to bruising and premature decay. Unloaded litchis should be kept under a shaded area to avoid direct sunlight, which can accelerate pericarp browning and reduce freshness. Handling should be gentle, ensuring that crates are not dropped or roughly handled, as impact damage can cause microcracks in the skin, increasing susceptibility to fungal infections and reducing market value. It is advisable to use well-ventilated crates during unloading and transfer to allow proper airflow and prevent heat accumulation. Efficient and careful unloading ensures that litchis retain their delicate texture, flavor, and color while allowing a seamless transition to the cooling stages, ultimately preserving quality and reducing spoilage.

b. Fruit Inspection

The initial inspection by a quality supervisor, where fruit data on maturity and defects are recorded, is a critical step in the litchi packhouse process. This step ensures that only fruits meeting the established quality standards proceed to the next stage, which helps maintain the overall quality and consistency of the product. By identifying and removing defective or infected fruits early, the inspection minimizes the risk of contamination and spoilage, reduces waste, and enhances the marketability of the final product. (APEDA, 2007)

c. Sorting & Grading

Sorting is a critical step where damaged or inferior fruit is removed, requiring careful examination under good lighting. Fruit with pulled stems, splits, cracks, insect damage, or any signs of rot should be rejected to prevent the spread of rot to sound fruit within the package.

In the final stage, the fruits are graded based on size, weight, colour, and maturity to meet diverse market preferences. As a practice, red-colored fruit weighing 25-30 gm is graded as Grade A, less than 25 gm weight as Grade B, and discolored ones as Grade C. Most producers use at least two grades of fruit, with grading typically occurring during or after sorting. Grading systems vary based on market requirements but generally focus on fruit size, color, and blemish area. Export markets usually demand higher standards, requiring uniform and unblemished fruit compared to domestic markets. Additionally, variations may exist within different segments of the domestic market.

As per the 2004 Fruits and Vegetables Grading and Marking Rules, the designated grade and quality for exported litchis are as follows:

(i) Litchis must be:

- Whole, sound, and fresh.
- Clean and free from visible foreign matter.
- Free from pests, pest damage, abnormal external moisture, and foreign smells/tastes.
- Exempt from damage, abrasion, and brown markings.

(ii) Litchis should have a minimum equatorial diameter of 23 mm.

(iii) Litchis must adhere to Codex Alimentarius Commission standards for heavy metals, pesticides, and other food safety parameters for exports.

Litchis can be presented individually with a cut pedicel, and the stalk must not extend more than 2 mm beyond the fruit's top. Alternatively, they can be presented in bunches, with each bunch comprising more than three attached and well-formed litchis, and the branch should not exceed 15 cm in length. (Horticulture Mission for North East and Himalayan States)

Table 3: Details of various classes of litchi as per AGMARK standards

Grade designation	Grade requirements	Grade tolerances
Extra class	Litchis must be of superior quality. They must have the shape, development, and colouring that are typical of the variety and/or varietal type. They must be free of defects, with the exception of very slight superficial defects, provided these do not affect the general appearance of the produce, the quality, the keeping quality, and the presentation in the package.	5% by number or weight of Litchis not satisfying the requirements for the grade but meeting those of Class I grade or exceptionally coming within the tolerances of that grade.
Class I	Litchis must be of good quality. They must be characteristic of the variety and/or commercial type. The following slight defects, however may be allowed provided these do not affect the general appearance of the produce, the quality, the keeping quality, and presentation in the package - slight defects in shape - slight defects in coloring; - slight skin defects Provided these do not exceed a total area of 0.25 sq. cm	10% by number or weight of Litchis not satisfying the requirements of the grade, but meeting those of Class II grade or, exceptionally coming within the tolerances of that grade
Class II	This grade includes Litchis, which does not qualify for inclusion in the higher grades but satisfies the minimum requirements specified in general characteristics. The following defects may be allowed, provided the Litchis retain their essential characteristics as regards the quality, the keeping quality and presentation. - defects in shape, - defects in colouring, - skin blemishes, provided these do not exceed a total area of 0.5 sq. cm.	10% by number or weight of Litchis not satisfying the requirements of the grade, but meeting the minimum requirements

Source: TMNEHS

Table 4: Size is determined by the maximum equatorial diameter

Grade	Minimum Equatorial diameter (in mm.)
Extra class	33
Class I	28
Class II	23

Source: TMNEHS

d. Washing and Cleaning

Litchi fruits are soaked in a chlorine solution (10-20 ppm) for 2-5 minutes, followed by scrubbing with revolving brushes. They are then rinsed with clean water and inspected to remove any damaged fruits.

e. Packaging

Litchis are often packed in small bamboo baskets or wooden crates for domestic markets. In Asia, bamboo crates/baskets are commonly used as they provide good protection against injury, with square baskets under 30 cm in height offering the best protection. Circular baskets can be enhanced with strings and padding, though water loss is a concern, which can be mitigated by lining or covering with a tarpaulin. Larger operations prefer plastic trays or cardboard boxes for better water control.



Figure 5: Litchi packaging for local market

Source: TMNEHS

Proper packing is essential for maintaining freshness during transit. Boxes lined with litchi leaves or soft materials like wood wool are recommended, with Sissum leaves being particularly effective. Ideal boxes should be light, shallow, rigid, and ventilated, with rope handles. Non pre-conditioned litchi fruits are packed in clusters with leaves. Plastic packaging with temperature control or fungicides is advised; however, without temperature control, plastic covers may cause condensation and increase the risk of rot. (Horticulture Mission for North East and Himalayan States)

Table 5: Specification details for Corrugated Fibre Board (CFB) Boxes for packing litchis for exports

Characteristics	Requirements	
	2 Kg	4 kg
Dimension	270X150X100	375X275X100
Material of construction	3 Ply Corrugated fibre board	3 Ply Corrugated fibre board
Grammage (g/m sq), Min (outer to inner)	*230/140/140	*230/140/140
Bursting strength kg/cm sq, Min	6.00	10.00
Puncture resistance, ozs inches/tear inch Min	100	250
Compression strength, kgf, Min	225	350



Figure 6: Litchi Carton Box

Source: PMAS Arid Agriculture University Rawalpindi, Pakistan

f. Palletization

Palletization is an essential part of packaging, particularly in the cold chain, where the box serves as the primary or secondary package, and the pallet acts as the tertiary package. Palletizing improves handling efficiency and reduces physical damage by minimizing the need for individual carton handling.

Boxes should be stacked in a vertical column pattern, with ventilation holes are aligned to facilitate air to circulate and pass through each box.

This arrangement helps ensure that cold air reaches every carton, allowing the produce to cool evenly and quickly and dissipate any gas pockets that may build up. Poor alignment or excessive compression can block these ventilation paths, causing temperature variations that may lead to inconsistent cooling, hot spots, ethylene or moisture buildup, potentially affecting fruit quality.



Figure 7: Palletization

Source: Rajendra Agricultural University

Vertical column palletization with proper carton ventilation allows for forced-air precooling in 2 to 3 hours. Cartons should be stacked for normal cold room cooling to allow air movement, taking 8 to 12 hours. Export pallets are typically 800 mm x 1200 mm or 1000 mm x 1200 mm, ensuring strength for transit. A standard pallet height is 180 cm, accommodating 320-400 cartons of 2 kg weight. If 250 g plastic punnets are used for packing, they are first arranged in a 5 kg box accommodating 20 punnets. Subsequently, small pallets of 50 kg size are created, each comprising 10 such boxes. Finally, by assembling 20 small 50 kg pallets, a large pallet of 1-ton (1000 kg) size is prepared for dispatch to the importing country. (P K Ray, 2004)

g. Labelling

Labeling is essential at both the box and pallet levels, with each box required to display the country of origin, product, variety, grade, net weight, exporter and importer names, as well as a phytosanitary inspection note. Pallet labeling can be done either before or after the pre-cooling process, depending on the final destination. Accurate labeling ensures traceability and quality control throughout the cold chain, ensuring compliance with domestic and international standards.

For litchi packed for domestic markets, growers must mark the box top with:

- Grower or packing establishment name.
- Street/road and area (not postal address).
- Litchi variety, class, and count (if in cartons).
- Date of packing.

h. Pre-cooling

Pre-cooling is a critical step in post-harvest management, designed to remove the field heat accumulated during harvesting. This process is essential because it significantly slows the fruit's respiration rate, reducing deterioration and extending shelf life. The primary goal of pre-cooling is to quickly reduce the temperature, which is vital for maintaining the fruit's quality during storage and transportation.

To remove field heat, litchi fruit requires pre-cooling through methods like hydro-cooling or air-cooling. Due to its high perishability, pre-cooling is crucial, since harvest temperatures range from 25-30°C with 40-45% relative humidity, leading to rapid desiccation during storage. Hydro-cooling is more efficient than air-cooling, reducing internal fruit temperature to 5°C within 18 minutes. Pre-cooling has been shown to extend selling life to up to 14 to 27 days when stored at 5°C. Additionally, pre-cooling treatments, combined with additives like lecithin and sodium bicarbonate, enhance color retention for storage up to 8 days at room temperature (25°C). Effective pre-cooling, especially hydro-cooling at 0-2°C, proves beneficial for litchi post-harvest life when continuously maintaining the prescribed temperature throughout the cold supply chain till it reaches the end consumers. (Horticulture Mission for North East and Himalayan States)

However, it's important to note that pre-cooling is not always necessary, especially for the fruit destined for nearby markets, i.e., within a day. In all cases, where the fruit is expected to reach consumption within 48 to 60 hours, the costs and logistical efforts of pre-cooling may outweigh the benefits of pre-cooling. For longer journeys or when litchis are destined for distant domestic markets and export markets, pre-cooling becomes an indispensable part of the post-harvest process, ensuring that the fruit remains in optimal condition throughout its journey till it reaches the consumers.

i. Staging cold room

The staging cold room is an insulated and refrigerated chamber that serves as a transient staging space, typically attached to a pre-cooling unit. It is a necessary component of modern packhouses, especially at the farm gate, where it temporarily stores preconditioned fresh produce while awaiting transport to a distribution point or cold store near the market. The staging cold room ensures an efficient workflow by freeing up the pre-cooler space for the next batch of freshly harvested litchi. The purpose of staging cold storage is to maintain the fruit's temperature and freshness until it is evacuated, not for long-term storage



Figure 8: Litchi Cold Storage

Source: TMNEHS

Litchi's are commonly stored at 5°C with 95% R.H. Fruits treated with 2% sodium hypochlorite can be satisfactorily stored in perforated polythene bags at 0-30°C for 25 days. For domestic consumption centers, the fruit can be maintained at 7°C in cold distribution hubs near the markets, which is a more energy-efficient practice. This setup ensures that the litchis remain fresh without unnecessary energy expenditure, as they will be quickly consumed. Conversely, for export markets requiring longer storage (up to 27 days), litchis are maintained at 5°C. Maintain a relative humidity of 90-95% during storage and transport. Controlled atmosphere storage (3-5% O₂ and 3-5% CO₂) minimizes skin browning and slows acid, ascorbic acid, and soluble solids losses. However, exposure to oxygen levels below 1% and/or carbon dioxide levels above 15% may lead to off-flavors and a dull gray pulp appearance. (Horticulture Mission for North East and Himalayan States)

j. Loading

Proper loading of litchi before transport is critical to maintaining the cold chain and preventing quality deterioration. Prior to loading, the packed litchi should be moved to the ante-room to stabilize its temperature and prevent thermal shock when transitioning to a refrigerated vehicle. The ante-room acts as a buffer zone, minimizing temperature fluctuations and condensation risks that could otherwise lead to pericarp browning and fungal growth.

At the loading dock, the environment should be temperature-controlled and shaded to avoid unnecessary exposure to heat. Litchi crates should be loaded swiftly but carefully, ensuring minimal handling to prevent bruising. The use of pallets or trolleys is recommended to avoid dragging or dropping crates, which can lead to mechanical damage. Stacking should allow for proper ventilation, ensuring uniform air circulation inside the vehicle to maintain optimal storage conditions.

During loading, it is essential to maintain a clean and hygienic environment, ensuring that all packaging is intact and free from any contaminants. The doors of the refrigerated vehicle should remain closed when not actively loading to retain the desired temperature. Once loaded, the cooling system should be stabilized before departure to ensure that the litchi maintains its ideal transit temperature, preserving freshness and extending shelf life.

k. Transport

To ensure the produce maintains its quality during transit to distant markets, refrigerated transport is necessary from the pre-cooling point at the packhouse to the destination markets, considering the concentrated production area and the distance the produce has to travel to reach the consumption center. For nearby local markets, harvested litchi are packed and transported by non-reefer trucks.

However, for longer distances, the use of multi-modal transport systems—involving combinations of air, road, rail, and sea transportation—plays a vital role in ensuring efficient and cost-effective delivery while maintaining quality. Road Transport (Reefer Trucks) is the most commonly used method for transporting fresh produce from packhouses to local or regional hubs. Refrigerated train carriages can transport large volumes of litchis while maintaining the cold chain over extended distances, reducing both transportation costs and environmental impact compared to trucks. Litchis are generally exported by air, but sea shipment is also possible with effective cold chain management. Transport to the airport, especially for cooled fruits, should utilize cool reefer vehicle and be covered to shield from wind, rain, and sun. Air shipments use aircraft containers or pallets, and precautions against heat build-up are essential, requiring shaded or cool storage conditions until loading. (P K Ray, 2004)

4.2 Fumigation

Litchi experiences rapid deterioration post-harvest, with pericarp browning being a significant issue, making the fruit unsuitable for the market. Browning is linked to desiccation, exacerbated by peroxidase activity and ascorbic acid oxidation, leading to anthocyanin degradation. To mitigate browning, sulfur dioxide (SO₂) fumigation is employed, resulting in a bleached pericarp that turns uniformly pink after 2-3 days. Sulphitation is performed by fumigating litchi fruits with sulfur dioxide gas in a closed chamber for 45 minutes. The sulfur dioxide is generated by igniting pure sulfur powder at a rate of 300 mg of sulfur per kilogram of fruit. (Global AgriSystem Private Limited, 2021)

For domestic premium or export markets, fumigation may be required based on buyer requirements. Fumigated fruits absorb 30-65 percent of applied SO₂. Residual sulfur is a concern, with a limit of 10 ppm. It is not approved for use on Litchi marketed in the U.S.A. For sea transportation, 600-650g of sulfur for 50-60 minutes is recommended; for air transport, 300-400g of sulfur for 30 minutes is advised. (H.P. Singh and S. Babita)

4.3 Activities for Export Market

a. Acid Dip (New Innovative Israeli Technology)

Acid Dip is an innovative technology originating from Israel. In this method, acid solutions such as Oxalic acid (0.25%, 1%, 5%, 10%), Nitric acid (0.5%, 1.5%), Phosphoric acid (4%, 6%, 8%), and a salt solution, Calcium Nitrate (2%, 3%), are prepared in distilled water. Litchi fruits are immersed in these solutions based on the treatment, with a fruit-to-solution ratio of 1:3. Vietnam has adopted and excelled in this technology, becoming the world's leading exporter despite lower production compared to India and China. This innovative approach extends the shelf life of litchi fruits up to 3 months without altering their color, resulting in an aesthetically pleasing appearance. Consequently, this technology is highly recommended for enhancing shelf life and freshness and facilitating export. (Global AgriSystem Private Limited, 2021)



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