# Optimising Orange Quality Through Postharvest Warehousing Systems

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## ABSTRACT

This study aims to analyse the implementation of postharvest warehousing operations in maintaining orange quality and supporting the distribution of horticultural products to consumers. The research employed a qualitative descriptive approach through field observations and interviews with warehouse owners and workers directly involved in operational activities. The findings reveal that the warehousing system has implemented integrated operational stages consisting of put away, storage, receiving, picking, ancillary activities, packing, and shipping. The storage stage emerged as the most critical process due to its role in maintaining product quality through controlled air ventilation and fruit ripening during the storage period. In addition, the application of grading based on fruit quality contributed to market segmentation and helped preserve the commercial value of the products before distribution. The study also found that most warehouse activities were still conducted manually, potentially increasing the risk of distribution delays and inventory management errors when demand volume rises. Therefore, the development of simple digital inventory recording systems and more modern storage management practices may serve as alternative strategies to improve the operational effectiveness of horticultural warehousing in the future.

**Keywords:** Orange warehousing, postharvest quality, product distribution, storage management, warehousing systems.

## INTRODUCTION

Warehouses are essential facilities within logistics and supply chain activities, functioning as centres for the storage, management, and distribution of goods before they are delivered to consumers or other parties. In business operations, warehouses are not merely utilised for storing raw materials, semi-finished goods, or finished products, but also play a significant role in ensuring the continuity of production and distribution processes. An effective warehousing system can assist companies in reducing the risk of product damage, accelerating distribution flows, and improving operational efficiency. Within the agribusiness sector, particularly in horticultural commodities such as oranges, warehouses perform a more complex function as they are closely associated with postharvest handling aimed at maintaining product quality, freshness, and market value prior to distribution. Inappropriate handling during the storage process may result in quality deterioration and even product spoilage; therefore, an effective and structured warehouse operational system is required (Bartholdi & Hackman, 2014; Wills et al., 2007).

Research concerning warehouse operational systems has expanded across various industrial sectors. Warehouse operations are considered complex activities as they involve storage management, product rearrangement, and efforts to reduce distribution lead times (Bartholdi & Hackman, 2014). These processes generally consist of several principal activities, namely receiving, put away, storage, picking, packing, and shipping, as well as additional ancillary activities such as labelling, re-packing, repairs, and assembly. Receiving refers to the process of accepting goods, including inspection, quality control, and determining storage locations (Paul & Lestari, 2015). Subsequently, put away activities involve transferring products into designated storage areas while systematically recording product quantities and storage positions. Storage activities constitute the core of warehousing systems, as they relate not only to product storage but also to supporting receiving, picking, and product inspection processes. Furthermore, picking activities involve transferring products from the warehouse to consumers, while packing activities are associated with product packaging and sorting prior to distribution. The final stage, shipping, refers to product delivery to consumers through inspection, loading, and transportation processes using designated transport facilities (Bartholdi & Hackman, 2014).

Previous studies have demonstrated that the effectiveness of warehousing systems significantly influences distribution quality and supply chain efficiency within companies. Faber et al., (2013) eported that effective warehouse management can improve operational productivity and reduce product damage during storage processes. Meanwhile, research within the horticultural sector has primarily focused on postharvest handling aspects, including temperature control, humidity management, and storage techniques aimed at maintaining fruit quality, ensuring product suitability for consumption, and enhancing market competitiveness (Kader, 2002; Wills et al., 2007). Nevertheless, most previous studies have concentrated on warehousing systems within manufacturing industries and general distribution sectors, whereas research examining the implementation of orange warehouse operational systems at the local business scale remains relatively limited. This condition indicates the existence of a research gap, particularly regarding the application of warehouse operational activities to orange commodities, which are highly perishable and require specialised postharvest handling.

Based on these conditions, this study focuses on analysing the warehouse operational processes of an orange producer in Lembang as part of the postharvest handling and distribution system for horticultural products. The research problem is formulated around how warehouse operational processes, including receiving, put away, storage, picking, packing, ancillary activities, and shipping, are implemented to maintain fruit quality prior to distribution to consumers. Accordingly, this study aims to analyse the operational stages of orange warehousing and to identify the implementation of warehousing systems in supporting product quality and the smooth distribution of oranges in Lembang.

## METHOD

This study employed a qualitative descriptive approach to examine the operational processes of an orange warehouse in Lembang. The research was conducted directly at an orange management enterprise engaged in the storage and distribution of harvested products prior to their delivery to consumers. This approach was selected because the study focused on understanding warehousing activities as they occurred in practice, ranging from the receipt of products to the distribution process.

Primary data were collected through direct observations and interviews with the owner of the orange enterprise and warehouse workers involved in operational activities. Informants were selected using purposive sampling by considering individuals who possessed a comprehensive understanding of orange warehousing processes, including sorting, storage, packaging, and product distribution activities. The informants consisted of business owners and workers directly engaged in warehouse operational activities. The research instruments consisted of observation guidelines and semi-structured interview guidelines.

Observations were conducted to examine warehouse conditions, storage processes, and the distribution flow of oranges, while interviews were undertaken to obtain information regarding warehouse operational stages and the challenges encountered during storage and product distribution processes. In addition, documentation of operational activities was utilised as supporting research data. The collected data were analysed descriptively through the processes of data reduction, data presentation, and conclusion drawing. The analysis was carried out by comparing field findings with established warehousing operational concepts in order to obtain a comprehensive understanding of the implementation of orange warehouse operational systems in Lembang in maintaining postharvest product quality and distribution efficiency (Miles et al., 2014).

To enhance methodological transparency, the interview and observation data were subjected to thematic analysis. The analytical process began with the transcription and repeated examination of interview records in order to achieve familiarity with the collected information. Subsequently, an open coding process was conducted

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to identify meaningful statements related to warehouse operational activities, postharvest handling practices, quality control procedures, and distribution management.

The initial codes were then grouped into broader categories according to similarities in meaning and operational relevance. Through an iterative comparison process, several themes were identified, including warehouse operational flow, product quality management, storage practices, value-added activities, and distribution processes. These themes subsequently formed the basis for interpreting the operational characteristics of the orange warehouse and relating the findings to existing warehousing concepts and previous studies.

To ensure the credibility and trustworthiness of the findings, data validation was conducted through methodological triangulation. Information obtained from interviews was cross-checked against field observations and operational documentation collected during the study. In addition, member checking was undertaken by confirming key interpretations with selected informants to minimise potential misinterpretations and ensure that the findings accurately reflected actual operational practices. The combination of thematic analysis and triangulation procedures strengthened the reliability of the research findings and improved the overall rigour of the study (Nowell et al., 2017; Saunders et al., 2018).

Table 1. Interview Coding and Thematic Analysis Procedure

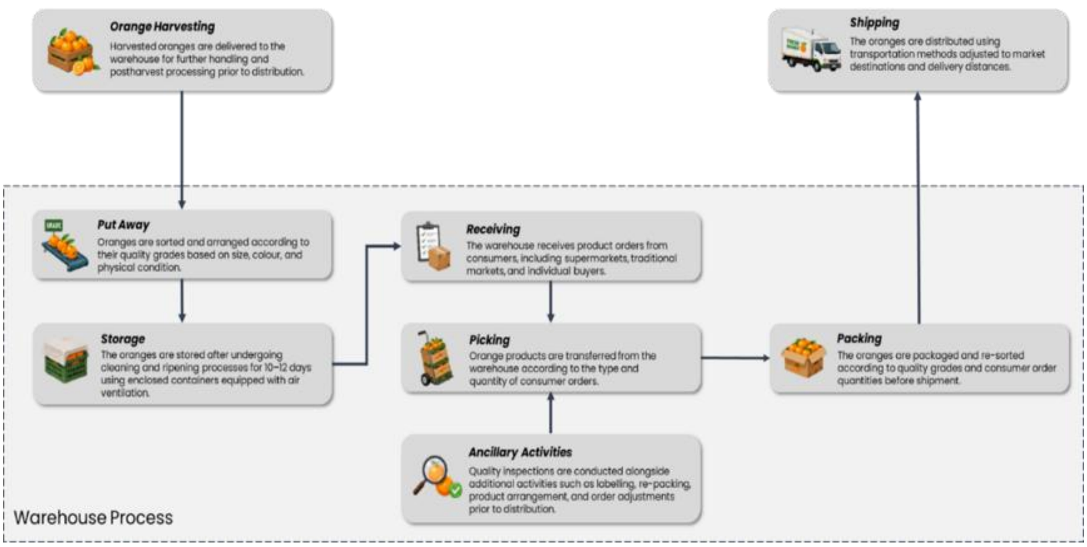
| Research Stage | Activity | Output |
|---|---|---|
| Data familiarisation | Reviewing interview transcripts, observation notes, and documentation | Initial understanding of warehouse operations |
| Open coding | Identifying significant statements and operational activities | Initial codes |
| Categorisation | Grouping similar codes into categories | Operational categories |
| Theme development | Identifying recurring patterns and relationships | Research themes |
| Interpretation | Relating themes to warehousing concepts and literature | Findings And Discussion |
| Validation | Triangulation and member checking | Credible and trustworthy findings |

## RESULT AND DISCUSSION

### Result

The operational flow of the orange warehouse is illustrated in Figure 1.

Figure 1. Operational Flow of Lembang Orange Producer Warehouse




The findings indicate that the operational activities of the orange warehouse function not only as a storage facility for harvested products, but also as a centre for postharvest quality control prior to distribution to consumers.

Based on field observations and interviews, the warehouse operational flow consists of several principal stages, beginning with orange harvesting and continuing through warehouse handling processes such as put away, storage, receiving, picking, ancillary activities, packing, and finally shipping. These processes are integrated to maintain the quality, freshness, and market value of oranges throughout the distribution process.

As presented in Figure 1 in above, the operational process begins with the harvesting of oranges, which are subsequently delivered to the warehouse for further handling. During the put away stage, the oranges are sorted and arranged according to quality grades. The sorting process is conducted by separating the fruit based on size, skin colour, ripeness level, and physical condition before entering the storage stage. This stage is particularly important because it determines market segmentation and the type of storage treatment applied to the products.

The subsequent stage is storage, which involves storing the oranges after undergoing cleaning and ripening processes for approximately 10–12 days. The oranges are stored in enclosed containers equipped with air ventilation systems to maintain stable air circulation throughout the ripening period. This storage system is intended to accelerate uniform fruit ripening while simultaneously reducing the risk of spoilage during storage. Following the completion of the storage process, the warehouse receives product requests through the receiving stage, primarily originating from supermarkets, traditional markets, and individual consumers.

During the picking stage, products are transferred from the warehouse according to the quantity and type of consumer orders. In addition, ancillary activities are carried out in the form of final quality inspections and supplementary processes such as labelling, kitting, re-packing, repairs, and assembly before the products are packaged. The packing stage is conducted by ensuring that both the fruit quality grades and the quantity of consumer orders correspond appropriately. Oranges of the highest quality are generally prioritised for supermarkets due to their stricter quality standards, whereas medium-grade products are distributed to traditional markets. The final stage, shipping, involves distributing the products using transportation methods adjusted to market destinations and delivery distances.

The findings demonstrate that the operational system of the orange warehouse has implemented a relatively structured postharvest management process, ranging from product sorting to final distribution. This system supports fruit quality control throughout the storage process and contributes to maintaining product freshness until the oranges reach consumers.

The findings demonstrate that the operational system of the orange warehouse has implemented a relatively structured postharvest management process, ranging from product sorting to final distribution. This system supports fruit quality control throughout the storage process and contributes to maintaining product freshness until the oranges reach consumers. To provide additional operational insight, the findings may also be interpreted through several warehouse performance indicators observed during the field study. Although the warehouse has not yet implemented a formal performance measurement system, several operational parameters can be identified from existing practices. The storage process was conducted for approximately 10-12 days, indicating a relatively consistent ripening period before product distribution. Product quality control was applied through grading, final inspection, and market-based product allocation, which contributed to reducing the risk of distributing fruit that did not meet consumer requirements.

The findings also suggest that customer order fulfilment was supported through the integration of receiving, picking, packing, and shipping activities. Orders received from supermarkets, traditional markets, and individual consumers were processed according to product grade and requested quantity, indicating an operational focus on order accuracy. Furthermore, the utilisation of different transportation modes according to market destination reflects an effort to maintain distribution responsiveness and delivery effectiveness. However, several important performance indicators could not yet be quantified because warehouse operations were still largely conducted manually and no systematic records were available. These indicators include postharvest loss percentage, inventory accuracy, customer order fulfilment rate, average distribution lead time, and product damage during storage. Previous studies have highlighted that the measurement of such indicators is essential for evaluating warehouse effectiveness and identifying opportunities for operational improvement within agricultural supply chains (Bottani et al., 2025; Ghaouta et al., 2023). Consequently, the implementation of simple performance monitoring mechanisms would enable future assessments of warehouse efficiency and strengthen data-driven decision-making in postharvest management.

Table 1. Observed Operational Performance Indicators of the Orange Warehouse

| Indicator | Observation from Field Findings |
|---|---|
| Storage duration | Approximately 10–12 days |
| Product grading | Conducted before storage and distribution |
| Quality inspection | Conducted during ancillary activities |
| Customer order fulfilment | Based on order quantity and product grade |
| Distribution system | Adjusted to market destination |
| Product loss percentage | Not systematically recorded |
| Inventory accuracy | Manual recording system |
| Distribution lead time | Not systematically measured |

## DISCUSSION

The findings presented in this study demonstrate that the operational system of the orange warehouse plays a strategic role in maintaining the quality of horticultural products throughout postharvest handling and distribution processes. The warehouse functions not merely as a storage facility, but also as a centre for quality control, packaging, and product distribution (Bartholdi & Hackman, 2014). These findings are consistent with the study conducted by Grinsted & Richards (2020), which emphasised that warehouse management for agricultural products should integrate storage processes, quality control, and distribution activities in order to minimise postharvest losses. In the present study, such integration was reflected through the implementation of sorting, quality inspection, ripening, and packaging processes based on market segmentation.

The put away and storage stages emerged as the most critical phases in preserving orange quality. The grading process indicated that the warehouse had implemented product classification in accordance with horticultural quality standards. According to horticultural quality guidelines, fruit grading generally considers factors such as size, skin colour, ripeness level, cleanliness, and physical damage (Ministry of Agriculture, 2021). In this study, oranges characterised by bright yellow colouration, uniform size, and good skin condition were prioritised for modern retail markets, whereas products of standard quality were distributed to traditional markets. This grading system demonstrates that warehouse management contributes to enhancing the economic value of products through differentiated market segmentation.

The findings further revealed that the use of enclosed containers equipped with air ventilation during the storage stage represented an important strategy for maintaining fruit quality throughout the ripening process. The ventilation system assisted in stabilising humidity levels and air circulation, thereby reducing the risk of product spoilage. In addition, the application of ethrel during the ripening process contributed to accelerating and standardising fruit maturity prior to distribution. These findings support the study by Pratama & Firdaus (2025), which explained that environmental control factors such as temperature, ventilation, and humidity constitute essential elements in preserving the quality of horticultural products throughout the distribution chain.

During the ancillary activities and packing stages, the study identified additional processes including final quality inspection, labelling, and repackaging prior to product distribution to consumers. These activities indicate that the warehouse had implemented value-added services within the horticultural supply chain. According to Jedermann et al., (2014), the implementation of additional handling activities within fresh-product warehouses can improve distribution accuracy, preserve product quality, and extend shelf life during transportation. In this study, packing activities were also adjusted according to order quantity and market destination, thereby helping to reduce the risk of product damage throughout the distribution process.

The final stage, namely shipping, demonstrated that the distribution system was conducted flexibly according to market destination and delivery distance. The use of different transportation methods for supermarkets and traditional markets reflected adjustments to varying consumer requirements. This condition indicates that warehousing systems are not solely associated with product storage, but also contribute to distribution efficiency and customer service performance. These findings are consistent with the study conducted by Rani et al., (2026), which reported that the effectiveness of horticultural warehouse management influences distribution efficiency, reduces postharvest losses, and enhances the competitiveness of agricultural products.

Another significant finding of this study is that the majority of warehouse operational activities were still conducted manually, particularly in relation to sorting, product handling, and stock recording processes. Such conditions may increase the risk of distribution delays and inventory management errors, particularly when demand volume rises. Furthermore, the absence of temperature monitoring systems and digital recording mechanisms may affect the effectiveness of quality control during storage. Within modern horticultural warehouse management, the application of digital inventory systems, storage temperature sensors, and efficient warehouse layout arrangements has become essential for improving operational efficiency and reducing postharvest product losses (De Corato, 2020). Therefore, the development of simple technology-based warehousing systems and the enhancement of human resource capacity represent important measures for supporting the sustainability of orange warehouse management in the future.

The findings of this study provide valuable insights into the operational practices of a conventional orange warehouse; however, the results should be interpreted within the context of a single warehouse case. The operational processes observed in this study relied predominantly on manual handling, visual quality inspection, and paper-based stock management. While such practices remain common among small and medium-sized horticultural enterprises, technology-based warehousing systems have increasingly adopted digital inventory management, barcode tracking, environmental monitoring sensors, and automated quality control mechanisms to improve operational visibility and decision-making accuracy (Andiyappillai, 2020; Nandi et al., 2020).

The comparison between conventional and technology-supported warehousing highlights potential opportunities for operational improvement. Conventional warehousing systems generally offer lower investment costs and greater flexibility in labour-intensive activities, whereas technology-based systems provide advantages in inventory accuracy, traceability, storage monitoring, and distribution responsiveness. In the context of horticultural products, the integration of digital monitoring technologies may contribute to reducing postharvest losses, improving stock control, and enhancing product quality consistency throughout the supply chain (Tikwayo & Mathaba, 2023).

An additional aspect that warrants consideration is the potential application of cold chain technology within horticultural warehousing systems. Unlike conventional storage practices, cold chain systems maintain products within controlled temperature ranges throughout storage, handling, and transportation processes. Such systems are particularly important for perishable commodities, including citrus fruits, as temperature fluctuations can accelerate respiration rates, moisture loss, physiological deterioration, and microbial activity, ultimately reducing product quality and market value (Islam et al., 2022).

The warehouse examined in this study relied on ambient storage conditions supported by air ventilation during the ripening period. While this approach appeared effective in facilitating fruit maturation and maintaining product quality for local distribution, the absence of temperature-controlled storage may limit the ability to preserve quality over longer storage durations or extended distribution distances. Previous studies have demonstrated that cold chain implementation can significantly reduce postharvest losses, extend shelf life, improve product uniformity, and enhance supply chain reliability for fresh horticultural products (Bambalele et al., 2021; Ndraha et al., 2018).

From an operational perspective, the adoption of cold chain technology does not necessarily require large-scale investments at the initial stage. Small and medium-sized horticultural enterprises may benefit from gradual improvements, such as temperature monitoring devices, insulated storage facilities, or refrigerated transportation systems. These technologies can contribute to better inventory management, more consistent product quality, and improved customer satisfaction. Therefore, integrating cold chain practices with digital warehousing technologies represents a promising pathway towards more sustainable and resilient postharvest management systems.

Given that this study focused on a single orange warehouse, the transferability of the findings to other horticultural warehousing environments should be approached with caution. Future studies could strengthen external validity by involving multiple warehouse locations, different scales of operation, and comparative analyses between conventional and technology-based warehousing systems. Such an approach would provide a broader understanding of operational performance variations and the role of technological adoption in supporting sustainable postharvest management.

## CONCLUSION AND SUGGESTION

This study demonstrates that the operational system of the orange warehouse plays a strategic role in supporting postharvest product quality and ensuring the smooth distribution of fruit to consumers. The findings reveal that the implementation of warehousing operational stages, including put away, storage, receiving, picking, ancillary activities, packing, and shipping, has established an integrated product management flow that contributes to maintaining orange quality throughout storage and distribution processes. Product sorting based on quality grades, air ventilation control during the ripening process, and packaging practices adjusted to market segmentation emerged as the principal factors supporting the preservation of product quality and the commercial value of horticultural commodities. These findings indicate that the warehouse functions not only as a storage facility for harvested products but also as a centre for quality control and postharvest product distribution.

The study further indicates that the storage stage represents the most critical aspect in preserving orange quality. The use of enclosed containers equipped with air ventilation systems contributes to maintaining humidity stability and promoting a more uniform ripening process, thereby preserving fruit quality throughout distribution activities. Furthermore, the implementation of grading based on colour, size, and physical condition demonstrates that warehousing systems influence market segmentation and product economic value. These findings emphasise the importance of consistent quality control practices within horticultural warehousing operations to maintain product competitiveness and consumer acceptance throughout the distribution chain.

Another important finding is that most warehouse operational activities remain highly dependent on manual processes, particularly in sorting, product handling, and stock recording. Such conditions may increase the risk of distribution delays, inventory discrepancies, and product deterioration when demand volumes increase. Consequently, the development of simple digital inventory recording systems, more efficient warehouse layouts, and enhanced workforce capacity in postharvest handling should be considered as practical measures to improve warehouse operational effectiveness and support the long-term sustainability of horticultural warehousing systems.

Despite these contributions, several limitations should be acknowledged. The study was conducted within a single orange warehousing enterprise in Lembang, and therefore the findings may not fully represent operational conditions across different horticultural commodities, geographical regions, or warehouse scales. In addition, the qualitative descriptive approach adopted in this research focused primarily on understanding operational practices and postharvest management processes rather than measuring quantitative warehouse performance. As a result, operational indicators such as postharvest loss rates, inventory accuracy, customer order fulfilment performance, storage efficiency, and distribution lead times could not be systematically evaluated. The study also did not examine the operational implementation of digital warehousing technologies, automated inventory systems, or cold chain infrastructure, which may influence warehouse performance and product quality preservation.

Future research is therefore encouraged to involve multiple warehouse locations, different operational scales, and comparative assessments between conventional and technology-based warehousing systems. Further studies may incorporate measurable operational performance indicators, including postharvest loss percentages, inventory accuracy, customer fulfilment rates, storage efficiency, and distribution lead times, in order to strengthen the practical implications of warehousing research. Moreover, investigating the adoption of digital warehousing technologies and cold chain systems within horticultural supply chains would provide a broader understanding of sustainable postharvest management strategies and support the development of more resilient and efficient warehousing operations.

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