



Strategies for Utilizing Cold Storage Technology in Maintaining the Quality and Quality Standards of Horticultural Vegetables After Harvest (Case Study of CV. Family Garden Mart)

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Abstract

This study aims to determine how the strategy of utilizing cold storage technology in maintaining the quality and quality standards of post-harvest horticultural vegetables and to find out what quality standards and quality standards of horticultural vegetables are applied by the company. This research was conducted from January 2024 to April 2025. This research is a case study, with the owner of CV Family Garden Mart serving as the primary source of information required by the researcher. The data obtained were analyzed using qualitative descriptive analysis. The results of this study indicate that the treatment applied to vegetable products includes product inspection, weighing, packaging, determining the storage position in cold storage, setting the temperature, maintaining the cleanliness of the storage room, and implementing the FIFO (First In, First Out) system. The company uses cold storage with an area of 15.39 m² and a volume of 41.55 m³, and the storage temperature used is between 0-4°C, which can maintain the shelf life of vegetables for 2-3 weeks. Observations show that the company sets quality standards for each type of vegetable, namely red peppers (Quality II), yellow peppers (Quality I), broccoli (Quality I), potatoes (Quality II), tomatoes (Quality I), and carrots (Quality I). Based on the analysis of the relationship between technical parameters and vegetable quality, it was found that the technical aspects of storage and packaging have a strong relationship with the final quality of the product compared to other parameters.



Keywords: *Strategy, Cold Storage, Quality, Horticulture*

INTRODUCTION

The agricultural sector is a key pillar of national economic development, with the horticulture sub-sector making a significant contribution, particularly through vegetable commodities. These commodities not only have advantages in terms of productivity but also in terms of high competitiveness, especially in a stable economy without recession (Septiadi and Nursan, 2020). In Indonesia, vegetable commodities are one of the most widely cultivated horticultural products due to their high economic value and continuously increasing market demand. However, the physiological nature of vegetables, which are highly perishable, makes them highly vulnerable to post-harvest damage. If not properly handled after harvest, vegetables can suffer damage due to physical, chemical, microbiological, and physiological factors (Tahir, 2023).

The damage was mostly caused by metabolic processes that continued after harvesting, which depleted the food reserves in the vegetables. Additionally, other factors such as reduced moisture content, mechanical damage, evaporation, and microbial contamination can also lead to a decline in quality and an increase in post-harvest loss (Isnaeni, 2021). Therefore, proper post-harvest handling is essential to maintain quality and extend the shelf life of vegetables.

As public awareness of the importance of consuming fresh and healthy vegetables increases, the horticulture industry in Indonesia is experiencing rapid growth. Vegetables are now seen not only as a food necessity but also as part of a healthy lifestyle. The quality and standard of vegetables are important aspects in creating a healthy and productive workforce (Masniadi et al., 2020).

CV. Family Garden Mart is one of the businesses in the horticultural vegetable distribution sector that has implemented *cold storage* technology as part of its post-harvest handling strategy. *Cold storage* technology plays an important role in maintaining the freshness, quality, and shelf life of products. Storage at controlled temperatures and humidity levels has been proven to slow down the rate of decay and maintain the quality of vegetables (Abriana and Laga, 2019).

According to Purbatin et al. (2023), in practice, *cold storage* technology does not only function as a storage medium, but also as an integral part of an efficient supply chain system. This technology enables producers to meet the quality standards expected by consumers while minimizing the risk of product damage. Therefore, it is important to understand the strategies employed in the utilization of *cold storage* technology to maximize its function in maintaining the quality and freshness of horticultural products. This forms the foundation for this study to further



examine regarding the strategies and application of *cold storage* technology in maintaining the quality of post-harvest vegetables.

METHOD

The research location is at CV. Family Garden Mart Company, Baruga District, Kendari City, Southeast Sulawesi Province. The researcher chose this location because CV. Family Garden Mart is a horticultural vegetable distribution company that has utilized *cold storage* technology in its operations. The research period is 5 months, from January 2025 to May 2025.

Informants for this study were selected using *purposive sampling*. The informants in this study were the owner of CV. Family Garden Mart, the head of the warehousing division, the head of the production division, and employees responsible for sorting and packaging activities, consisting of three (3) employees.

In this study, the researcher used three methods for data collection: observation, interviews, and documentation. The analysis stage conducted by the researcher involved creating a list of interview questions, data collection, and data analysis performed independently by the researcher. To determine the extent of information provided by the research informants, the researcher used several stages:

1. Preparing a draft of interview questions based on the elements of credibility that will be asked of the informants.
2. Conducting interviews with several informants.
3. Transferring research data in the form of a list from all questions asked to the informants.
4. Analyzing the results of the interviews conducted and adding documentation attachments.
5. Presenting the data in the form of narratives, tables, or diagrams.
6. Draw conclusions

RESULTS AND DISCUSSION

Strategies for Utilizing *Cold Storage* Technology

Product Treatment

The following are some of the treatments applied to products before and after being placed in *cold storage*:



Table 1 Product Treatment Strategy

Observation Variables	Data Analysis Results Based on Informants' Responses
Product Treatment	- CV. Family Garden Mart treats horticultural vegetable products both before and after they enter <i>cold storage</i>. - Product Treatment Before Entering <i>Cold Storage</i>: - Inspecting the products - Weighing the products - Packaging the products - Product Handling After Entering <i>Cold Storage</i>: - Determine the position/location of vegetables in <i>cold storage</i>. - Adjusting the temperature - Maintaining <i>cold storage</i> cleanliness - Implementing the FIFO (First In First Out) system - Product handling significantly impacts the quality and freshness of vegetables.

(Source: Primary Data After Processing, 2025)

Based on the analysis of the above data, CV. Family Garden Mart performs handling procedures on vegetables before and after they are stored in *the cold storage* to maintain their quality and freshness. Before storage, the vegetables are inspected, weighed, and packaged. After storage, the vegetables are positioned within *the cold storage*, temperature is regulated, cleanliness is maintained, and the FIFO system is applied. This treatment is crucial as it significantly impacts the freshness and quality of vegetables during storage.

Product Storage

Cold storage is a low-temperature storage facility used to maintain the freshness and quality of vegetables by slowing down the respiration process, decay, and the growth of microorganisms. CV. Family Garden Mart utilizes a cold storage facility measuring 5.7 x 2.7 x 2.7 meters, with a floor area of 15.39 m² and a volume of 41.55 m³, but its effective storage capacity is approximately 29.08 m³ due to the use of stacked storage with styrofoam insulation and baskets without shelves. Despite the limited access pathways, this storage system remains efficient because the foam serves as additional insulation and the baskets allow for good air circulation, thereby maintaining vegetable quality and ensuring optimal supply chain operations. The

following are some of the components involved:

Table 2. Role of Several Cold Storage Components

No	Component	Role
	 (Cold Room Controller)	In the construction of a cold room, a control module is required. Conventional control modules typically operate in a " " mode to issue commands to the compressor and evaporator, enabling them to function according to the target temperature and form a refrigeration system itself (Nugraha et al, 2024).
2.	 (Evaporator Unit)	The evaporator unit consists of an evaporator (heat exchanger) and a blower, where the evaporator releases cold energy and captures heat with the help of a blower that circulates air inside the cooling chamber (Supriyanto and Budiharti, 2008).
3.	 (Condensing Unit)	The main components of the condensing unit consist of a condenser, blower, filter, compressor, and expansion valve. The condenser is used to cool the refrigerant after it exits the evaporator located inside the cooling chamber, where the refrigerant is still in the vapor phase. To return to the liquid phase, the refrigerant must be cooled, causing the condensation process to occur (Supriyanto and Budiharti, 2008).
4.	 (Thermometer)	A thermometer is a device used to measure and display temperature. In a cold storage system, a thermometer functions as a temperature monitoring device to ensure that storage conditions remain in accordance with the required standards (Sudimanto, 2019).

Source: Secondary Data After Processing, 2025



The use of cold storage plays a crucial role for CV. Family Garden Mart in maintaining the freshness and quality of vegetables during storage and distribution. With controlled temperature and humidity levels, the company has been able to minimize vegetable damage rates to just 2.08% of the total intake of Rp1,001,733,660 in January 2025, demonstrating the effectiveness of the storage system implemented. However, the use of cold storage also presents challenges, such as high investment and operational costs, the need for trained labor, and the importance of regular monitoring of temperature and cleanliness in storage areas. Despite these limitations, cold storage continues to provide significant positive impacts, particularly in extending shelf life, preventing spoilage caused by microorganisms, and improving inventory management efficiency and the company's competitiveness in the horticultural market.

The results of this study are in line with the opinion (Huang, *et al.*, 2025) that "The selection of cold chain storage facilities must be tailored to the characteristics and needs of agricultural products. In addition, the planning of the type, number, location, and capacity of cold chain storage facilities needs to be based on the production potential and distribution patterns of agricultural products, so as to produce an efficient and optimal facility layout scheme.

Temperature Control

CV. Family Garden Mart utilizes cold storage technology at 0–4°C as its primary strategy to maintain the quality and standards of post-harvest horticultural vegetables. Although each type of vegetable has different temperature tolerances, this temperature range was chosen because it is still optimal for most of the stored commodities, with the application of a separation system using separate racks or containers to avoid negative interactions between vegetable types. The company regularly monitors temperatures daily to ensure storage stability, as fluctuations can occur due to door openings or the initial temperature of newly stored vegetables. With proper temperature control, the processes of wilting, spoilage, and microbial growth are slowed down, while maintaining the freshness, color, and weight of the vegetables. The implementation of cold storage is a crucial factor in the fresh vegetable supply chain, not only minimizing post-harvest losses but also improving distribution efficiency and product competitiveness in the market.

The results of this study align with the findings of (Dirapan, *et al.*, 2021) that "Too low temperatures can cause damage, while too high temperatures can accelerate decay. Therefore, determining the optimal storage temperature is key to maintaining the quality and freshness of vegetables." The results of this study also align with the opinion of (Saidi, *et al.*, 2021) that "To achieve good storage results, the temperature in the cooling room must be maintained at a constant level and avoid fluctuations. This can be addressed by using room insulation and



sufficient cooling equipment. Proper stacking methods and adequate air circulation significantly help reduce temperature variations.”

Vegetable Storage Life

Shelf life refers to the period of time during which a product is safe for consumption. For CV. Family Garden Mart, a company engaged in the distribution of horticultural vegetables, understanding and managing shelf life is crucial. Therefore, CV. Family Garden Mart implements proper storage systems, such as the use of *cold storage*, to slow down the respiration and decay processes of vegetables. As a result, the shelf life of vegetables can be extended, the potential for damage can be minimized, and quality is maintained until the product reaches the consumer.

Table 3. Percentage of Damage to Various Types of Vegetables During Storage in *Cold Storage* (January 2025)

No	Type of Vegetable	Incoming (kg)	Damaged (kg)	Percentage of Damage (%)
1	Red Bell Pepper	2	0.7	2.68
2	Yellow bell pepper	230	1.7	0.74
3	Broccoli	605.25	4	0.66
4	Potato	65.4	0.5	0.76
5	Tomato	38	2.25	5.92
6	Carrot	227.8	0	0.35

(Source: Primary Data After Processing, 2025)

Based on vegetable damage data from CV. Family Garden Mart, there is a significant difference in the durability of each horticultural commodity during storage in cold storage. Tomatoes were recorded as the vegetable with the highest damage rate of 5.92% of 38 kg, indicating that tomatoes are the most susceptible to damage. Conversely, carrots showed the best storage quality with a damage rate of only 0.35% of 227.8 kg, followed by broccoli (0.66%), potatoes (0.76%), yellow peppers (0.74%), and red peppers (2.68%). These differences reflect the physical characteristics of each vegetable as well as the effectiveness of the cold storage system implemented. The observation results also indicate that some vegetables were able to maintain quality attributes such as texture, color, and weight up to the second or even third week, indicating that the use of cold storage is sufficiently effective in extending shelf life and

maintaining post-harvest product quality.

The results of this study are in line with the opinion (Paath, *et al.*, 2017) that "Storage at low temperatures is an effective way to extend the shelf life of fresh produce, as it reduces respiration, aging, and microbial growth. Cooling slows down or prevents damage without interfering with the ripening process and slowing down wilting."

Implementation of Quality Standards and Quality Criteria for Vegetables

Based on observations, vegetable quality standards are an important reference in ensuring the quality and safety of horticultural products. These standards cover various aspects, such as freshness, size, color, texture, and nutritional content in accordance with the provisions established by the relevant institutions. With quality standards, vegetables marketed can meet consumer expectations and maintain competitiveness in the food industry.

Table 4. Quality Standards for Several Types of Vegetables at CV Family Garden Mart

Type of Vegetable	Quality	Condition	Quality Standards for Several Types of Vegetables (CV. Family Garden Mart)	
			Quality	Appearance
Bell pepper (red)	I	Fruit weight between 220–350 grams, firm texture, normal shape, bright glossy color, no defects.	II	
	II	Fruit weight between 150–200 grams, firm texture, normal shape, bright color, no defects.		
	III	Fruit weight between 80–140 grams, firm fruit texture, normal fruit shape, bright fruit color, no defects.		
	I	Fruit weight between 220–350 grams, firm texture, normal shape, bright shiny color, no defects.		

Bell pepper (Yellow)	II	Fruit weight between 150–200 grams, firm texture, normal shape, bright color, no defects.	I	
	III	Fruit weight between 80–140 grams, firm texture, normal shape, bright color, no defects.		
Broccoli	I	Smooth, even, and compact flower heads	I	
	II	No rot, uneven, and compact flower heads		
	III	No rot, uneven, and flower heads not compact		
	IV	Rotten, uneven, and flower heads not compact		
Potatoes	I	Color, shape, and size uniform, smooth skin surface, no dirt, and maximum 5.0% defective potatoes	II	
	II	Color, shape, and size are uniform; surface smoothness is not required; sufficiently mature; maximum impurity content of 2.5%; and maximum defect rate of 10%		
Tomatoes	I	Uniform shape and size, mature but not overripe, no dirt, maximum damage of 5%, maximum rot content of 1%.	I	
	II	Uniform shape and size, but the fruit is overripe and soft.		

Carrots	I	Free from defects/damage, free from woody root cores, with characteristic carrot root color from the base to the tip of the root.	I	
	II	Minor defects/damage permitted as follows: slight deviations in shape, green color at the base of the tuber up to 1 cm, defects/damage in the form of scratch marks and wounds on the surface of the tuber skin that do not affect the appearance of the product and quality, with a maximum total damage of 5% of the tuber's surface area.		
	III	Minor defects/damage permitted as follows: slight deviations in shape, green color at the base of the tuber up to 2 cm, defects/damage in the form of scratch marks and wounds on the tuber skin surface that do not affect the appearance of the product and quality, with a maximum total damage of 10% of the tuber surface area.		

(Source: Primary Data After Processing, 2025)

Table 4 shows that several types of horticultural vegetables at CV Family Garden Mart have met the highest quality standards based on established criteria. This reflects the company's efforts to maintain consistent product quality. The vegetables include red bell peppers of Grade II quality,

yellow bell peppers of Grade I quality, broccoli of Grade I quality, potatoes of Grade II quality, tomatoes of Grade I quality, and carrots of Grade I quality. With these quality standards in place, the vegetables sold can meet consumer expectations and maintain competitiveness in the food industry.

Vegetable Quality Standards and Technical Parameters

Vegetable quality standards are significantly influenced by the application of post-harvest technical parameters such as harvesting, collection, transportation, cleaning, sorting, packaging, storage, and delivery, ensuring that vegetable quality remains intact until it reaches the consumer. The following table shows the relationship between vegetable quality standards and technical parameters at CV. Family Garden Mart.

Table 5 Relationship Between Vegetable Quality Standards and Technical Parameters

Vegetable Quality	Technical Parameters							
	AP	BP	CP	DP	ES	FP	GP	HP
Cleanliness	+	+	+	+++	+++	+++	+++	+++
Freshness	+	+	+	+++	+++	+++	+++	+++
Safety	+	+	+	+++	++	+++	+++	+++
Durability	+	+	+	+++	++	+++	+++	++
Color	+	+	+	+++	+++	+++	+++	++
Size	+	+	+	++	+++	++	++	++
Shape	+	+	+	++	+++	+++	+++	++
Description: +: Weak relationship; ++: Moderate relationship; +++: Strong relationship. AP: Harvesting / BP: Collection / CP: Transportation / DP: Cleaning / ES: Sorting / FP: Packaging / GP: Storage / HP: Shipping								

(Source: Primary Data After Processing, 2025)

Table 5 shows that vegetable cleanliness attributes have a "strong" relationship with the technical parameters of cleaning, sorting, packaging, storage, and shipping, and a "weak" relationship with the technical parameters of harvesting, collection, and transportation.

1. The cleaning, sorting, packaging, storage, and shipping processes greatly affect the cleanliness of vegetables. Packaging is done according to the type of vegetable to prevent contamination, while storage uses cold storage to maintain quality from dust and microorganisms. Shipping is carried out using box trucks to protect vegetables from



extreme temperatures. However, during the harvesting, collection, and transportation stages, the role of CV. Family Garden Mart is limited as these processes are entirely handled by partner farmers.

2. Freshness attributes are strongly influenced by cleaning, sorting, packaging, and storage, moderately by transportation, and weakly by the initial processing by farmers. Cleaning prevents spoilage, sorting ensures that only the best products are stored, packaging maintains moisture and prevents damage, while storage slows down deterioration through temperature and humidity control. Short transportation maintains quality, though long-distance transportation can reduce quality.
3. Food safety is highly influenced by cleaning, packaging, storage, and transportation because these processes prevent contamination. Sorting plays a moderate role in food safety as it only separates damaged products, while the initial processes carried out by farmers have a weak influence. Proper handling at key stages ensures that vegetables are safe for consumption and enhances consumer confidence.
4. The shelf life of vegetables is strongly influenced by cleaning, packaging, and storage, while sorting and transportation have a moderate effect, and the initial processing stage has a weak influence. Cleaning according to vegetable characteristics prevents damage, while packaging and storage slow down the rate of respiration. Sorting separates damaged products, and long-distance transportation can reduce quality due to temperature changes.
5. The color of vegetables is strongly influenced by cleaning, sorting, packaging, and storage, moderately by transportation, and weakly by the initial processing stage. Cleaning restores the original color, sorting removes discolored vegetables, and packaging and storage maintain color stability. Local transportation preserves color- , while long-distance transportation tends to fade it due to duration and temperature.
6. Product size is greatly influenced by sorting and moderately influenced by cleaning, packaging, storage, and shipping. Sorting filters vegetables according to size requirements, cleaning includes trimming, and storage and shipping can reduce weight, although not significantly. The initial process carried out by farmers has little effect on the final size of the product.
7. The shape of vegetables is strongly influenced by sorting, packaging, and storage, moderately by cleaning and transportation, and weakly by the initial process. Sorting ensures uniform shape, packaging prevents deformation during distribution, and storage





maintains the physical structure of the product. Although cleaning and transportation have a moderate influence, shape stability depends more on other post-harvest stages.

The results of this study indicate that the technical parameters of packaging and storage at CV. Family Graden Mart have a strong average relationship with vegetable quality compared to other technical parameters. These findings align with the opinion of Arista (2021) that "Storage can be conducted at low temperatures to extend the shelf life of vegetables." Post-harvest activities are intended to maintain the quality of fresh products to remain optimal, thereby reducing losses due to shrinkage and damage, extending shelf life, and enhancing the economic value of agricultural products. Post-harvest handling efforts can also be carried out through packaging, which will slow down spoilage in vegetables.

CONCLUSION

Based on the research findings, it can be concluded that the utilization of *cold storage* technology is effective in maintaining the quality and standards of horticultural vegetables post-harvest. This is achieved through product handling procedures such as product inspection, weighing, packaging, determining the position/location of vegetables within *the cold storage*, temperature control, maintaining cleanliness of *the cold storage*, and implementing the FIFO (*First In, First Out*) system. With a capacity of 29.08 m³ and a temperature of 0-4°C, vegetables can be stored at an appropriate temperature to reduce the risk of damage and maintain freshness, color, and texture.

CV. Family Garden Mart applies quality criteria for vegetables, where red bell peppers are classified as Grade II, yellow bell peppers as Grade I, broccoli as Grade I, potatoes () as Grade II, tomatoes as Grade I, and carrots as Grade I. Meanwhile, the relationship between vegetable quality and technical parameters, specifically storage and packaging parameters, has a strong correlation with vegetable quality compared to other technical parameters.

The recommended strategy for improving vegetable quality is to prioritize improvements in shelf life, standard size and shape, color, and food safety. To support this, it is necessary to evaluate technical parameters, namely: ensuring cleaning with running water and *food-grade disinfectants-grade disinfectants*, implementing sorting according to standard size, color, and shape criteria along with visual *grading* training for workers, using appropriate packaging for product types and quality labeling for vegetables, strengthening the *cold storage* system with temperature and humidity control, and implementing the FIFO method, as well as using refrigerated transportation and efficient distribution routes.



Based on the research findings, the author recommends that CV Family Garden Mart continue to use *cold storage* technology and conduct regular evaluations of temperature, humidity, and storage duration to maintain consistent quality and standards for vegetables. The government is also encouraged to establish more detailed regulations or guidelines regarding quality standards and post-harvest handling of horticultural products, ensuring that all stakeholders in the distribution chain have uniform guidelines. Additionally, to obtain more comprehensive research results, further studies are recommended to conduct comparative analyses on several other horticultural distributors or producers to examine variations in strategies and the effectiveness of *cold storage* technology implementation.

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