Jurnal Penelitian
Journal homepage: https://jurnal.unmer.ac.id/index.php/jp
Volume 23 Issue 1, June 2026 | **76 - 95**

A Model for Enhancing Protein Food Supply Chain Efficiency Through Cold Chain Management in Jakarta

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Abstract

Food security, particularly concerning protein supply, is a strategic issue facing complex challenges in metropolitan cities like Jakarta. The protein supply chain is highly vulnerable to operational disruptions and climate fluctuations, which trigger price instability and product spoilage. This study identifies the gap between existing cold storage practices and the technology-based best practices needed to address these issues, especially in the context of implementing medium-scale industry solutions that can be adapted for Small and Medium-sized Enterprises (SMEs). Objectives: This study aims to analyze the current state of cold storage management, identify technology-based and non-technical best practices, and develop a model that integrates efficiency, sustainability, and risk management. The ultimate goal is to provide a guideline that can improve the operational performance, quality, and safety of the protein supply chain. Methodology: This study employs a mixed-methods approach with a case study design. Five years of historical data were used for quantitative analysis, supplemented by qualitative data from in-depth interviews with 11 warehouse staff and managers. An assessment of various operational aspects was conducted using a 1-10 scoring system to measure the impact of the transformation from previous to current conditions. Findings: The results of this study show a significant increase in the scores across all aspects of warehouse performance (from an average of 2.125 to 9.125), proving the success of the transformation. These improvements include the normalization of occupancy, enhanced goods flow, traceability, and temperature stability, which directly reduced food loss and operational risks. This transformation also had a positive impact on occupational health and safety (OHS) and organizational culture, which supported productivity and team morale. Practical Implications: This study offers a relevant and applicable best-practice model for SMEs in developing countries to enhance operational efficiency and sustainability. These findings provide valuable insights for managers and policymakers in Jakarta on the importance of strategic investment in cold chain transformation to support food security.

Keywords: Supply chain; Cold chain; Food industry; Operational management; Efficiency

Article Info

Received	:	2025-11-28
Revised	:	2026-07-28
Accepted	:	2026-07-30
Published	:	2026-08-03

DOI
10.26905/jp.v23i1.16465

How to cites

Rendy Riyanto, & sri wahyuni. (2026). A Model for Enhancing Protein Food Supply Chain Efficiency Through Cold Chain Management in Jakarta. *Jurnal Penelitian*, *23*(1). https://doi.org/10.26905/jp.v23i1.16465

INTRODUCTION

Background & Context

Food security is a strategic issue for metropolitan cities like Jakarta, which face complex challenges in maintaining the supply of essential goods, particularly protein products. (Rida Evalina Tarigan et al., n.d.). The protein supply chain, often originating from fisheries, livestock, and processed products, is highly vulnerable to various disruptions. Globally, food supply chains face significant risks from geopolitical uncertainty and economic shocks, which highlight the critical role of the logistics industry in economic stability (Fatorachian & Pawar, 2024; Tian & Liu, 2025). In Indonesia, supply instability has been a recurring problem, often caused by product damage, price volatility, and a lack of information throughout the supply chain (Rida Evalina Tarigan et al., n.d.).

In addition to operational challenges, the threat of climate change also places significant pressure on price stability and food availability. Studies show that climatic phenomena, such as rainfall and temperature variations, can have a measurable and significant impact on the supply of agricultural products, which in turn can trigger food price inflation (Lukashe & Nishimwe-Niyimbanira, 2025; Zhao et al., 2025). For instance, irregular rainfall can reduce crop yields, ultimately raising prices for consumers (Lukashe & Nishimwe-Niyimbanira, 2025). Therefore, the importance of optimal cold storage management to protect protein products from these external shocks becomes increasingly crucial.

In this context, the optimization of cold chain-based supply chain facilities becomes a key factor in ensuring product quality and supply sustainability (Pagliarini et al., 2025). However, the challenge, especially for regional-scale businesses, is how to achieve these goals effectively without burdening operational costs. (Ali et al., 2025; Kim et al., 2025). Cost savings can still be achieved, but the key is the optimization of utilization and the implementation of appropriate strategies. This can be accomplished through digital transformation that enables firms to identify and mitigate operational and information risks, thereby improving operational performance (Kim et al., 2025). This strategy can also effectively reduce food loss and food waste (Pigatto et al., 2025), a step that is not only economically beneficial but also contributes to better food security. The standardization of supply chain handling is also regulated by the Minister of Agriculture Regulation (Permentan) No. 11 of 2020 concerning the Certification of Veterinary Control Numbers for Animal Product Business Units. This regulation refers to Law No. 18 of 2009 in conjunction with Law No. 41 of 2014 concerning Livestock and Animal Health, which was subsequently issued (Kementrian Pertanian Republik Indonesia, 2020), as well as Government Regulation No. 95 of 2012 concerning Veterinary Public Health. This regulation mandates NKV certification as mandatory for all business units that produce or handle animal products, including both food and non-food items.

Although previous studies have extensively discussed cold chain logistics, digital transformation, warehouse management, and supply chain resilience, most studies focus on technology adoption and logistics optimization. Limited research integrates operational redesign, NKV regulatory compliance, and organizational change within a single framework for protein food supply chains in developing countries. This study fills this gap by proposing an integrated cold storage operational management model combining warehouse layout optimization, inventory flow improvement, cold chain integrity, organizational change, and regulatory compliance. The model demonstrates that substantial efficiency improvements can be achieved through systematic operational redesign supported by digital transformation without excessive infrastructure investment. This constitutes the theoretical and practical contribution of the study.

Research Problem

The main research problem is the gap between current cold storage management practices and the technology-supported best practices, which hinders the achievement of operational efficiency and sustainability of the protein supply chain. This problem is reinforced by several internal constraints that have persisted for many years. Therefore, the research question is: "How can digital transformation in

cold storage management improve the operational efficiency and sustainability of the protein food supply chain in Jakarta?"

The main issues that are the focus of this study can be identified as follows:

1. **Inefficient Goods Flow and Placement**. The stacking of goods at one point without a clear flow leads to a waste of space and time. This condition reflects a lack of organized warehouse management, which is a key factor in cold chain performance (Chermala et al., 2025). Inefficient goods flow can also cause undesirable temperature fluctuations and a decline in product quality (Pagliarini et al., 2025).
2. **Dense Storage Conditions Without Maneuver Space**. The dense stacking of goods, leaving no maneuver space for retrieval at all points within the chamber, is a significant operational challenge. Best practices in cold storage management emphasize the importance of space efficiency and accessibility to avoid product damage, which directly relates to the goals of operational management. (Chermala et al., 2025).
3. **Non-Ideal Supply Rotation**. The supply of raw materials and finished products has a non-ideal rotation, which leads to a high risk of product damage and significant food loss (He & Sun, 2025). This problem, which is common in food supply chains, requires smart optimization to reduce waste and increase firm profitability (Rida Evalina Tarigan et al., n.d.).
4. **Obstacles in Obtaining NKV Level-1 Certification**. The difficulty in obtaining certifications such as the Veterinary Control Number (NKV) level-1 indicates significant compliance risks. This is often caused by inadequate supervision and suboptimal quality control. (Ghafoor et al., 2025). The achievement of certification is a vital element of risk management and supply chain sustainability, which can improve financial performance and consumer trust. (Khalid et al., 2024; Kristanto & Kurniawati, 2025).
5. **Warehouse Team Apathy**. The apathetic condition among the warehouse team, resulting from unresolved long-standing issues, reflects the presence of psychological barriers and organizational culture problems in the transformation. This behavior can be understood through cognitive biases and deep-rooted habits, which are major obstacles to adopting new practices. (Purushothaman & Aguas, 2025). Therefore, this study will also consider the importance of digital leadership to overcome these human barriers and drive sustainable change. (Religia et al., 2024).

Research Objectives

Based on the identified operational problems, the main objective of this study is to develop and implement a model of best practices in cold storage management that can enhance the efficiency, sustainability, and resilience of the protein supply chain. Thus, this study specifically aims to:

1. **Optimizing Goods Flow and Storage Methods.** This objective focuses on improving inefficient goods flow, while considering the limitations of the warehouse's condition, existing technology, and chamber layout. Organized warehouse management is a key factor in cold chain performance. (Chermala et al., 2025). Developing appropriate storage methods to ensure the accessibility of goods to all points of the warehouse is crucial, as this will directly reduce the risk of product damage and food loss associated with temperature fluctuations. (Pagliarini et al., 2025).
2. **Improving Goods Rotation Effectiveness.** This research aims to find ways to accelerate the rotation and effectiveness of goods in the warehouse (raw materials and finished products). Non-ideal product rotation is a major cause of product damage and food loss. (He & Sun, 2025). By adopting appropriate best practices, a firm can significantly reduce waste, which not only increases profitability but also contributes to food security (Pigatto et al., 2025).
3. **Achieving Certification and Quality Standards.** This objective is to overcome the difficulties in obtaining certifications, such as NKV level-1 (Veterinary Control Number). This certification serves as proof of compliance with risk management and product quality standards. Achieving these standards will improve financial performance and strengthen consumer trust (Khalid et al., 2024; Kristanto & Kurniawati, 2025).

4. **Addressing Human and Cultural Barriers.** This study also aims to transform the warehouse team's mindset from apathetic to optimistic and proactive. This involves identifying and handling human barriers (cognitive biases) that hinder the adoption of best practices(Purushothaman & Aguas, 2025). Effective digital leadership is considered important for driving this transformation and overcoming resistance to change in the workplace (Religia et al., 2024).

RESEARCH METHODOLOGY

Research Approach

This study will use a mixed-method approach, which is a combination of qualitative and quantitative methods. This approach will allow us to analyze historical data (quantitative) to measure operational efficiency and performance, while also exploring contextual factors and human barriers (qualitative) that influence the cold storage transformation. This approach is aligned with similar research in the management field that aims to provide comprehensive insights (Lin & Wu, 2014).

Data Sources

Quantitative Data: The primary source will be the 5-year historical data you have. This data includes:

1. **Warehouse Occupancy Rate:** This data will be used to analyze space utilization and operational efficiency over time.
2. **Goods Flow and Placement Records**: This data will be analyzed to measure the impact of improvements in the flow and placement of goods inside the chamber.
3. **Human Resources Performance Data:** This data will be used to measure the productivity or engagement of the warehouse team. This can be in the form of performance data before and after the best practices were implemented, which we will analyze quantitatively.

Qualitative Data: This data will be collected to understand the context behind the numbers. It can come from in-depth interviews with managers and warehouse staff, as well as direct observation of operational processes. This approach is important for understanding the psychological and cultural barriers that exist, such as the apathetic mindset. (Purushothaman & Aguas, 2025; Religia et al., 2024).

DATA ANALYSIS

Quantitative Analysis:

Quantitative data were analyzed using descriptive statistics (mean scores, percentage improvement, and comparative analysis before and after implementation). Where appropriate, paired-sample t-tests may be applied to examine statistical significance. Qualitative data were analyzed using thematic analysis involving coding, categorization, and interpretation.

1. **Operational Efficiency:** We will analyze occupancy, flow, and placement data to measure operational efficiency and costs (e.g., a decrease in the time required to retrieve goods). We can use a Data Envelopment Analysis (DEA) model inspired by a journal (Sultan et al., 2025), or a simple statistical analysis (regression) to examine the correlation between changes in operational practices and efficiency outcomes.
2. **Human Resources Performance:** For this part, we can design a brief survey to measure the performance of the warehouse team after the improvements are implemented. The results of this survey can be analyzed quantitatively, for example, by comparing productivity data before and after the changes. This approach is aligned with research that measures the influence of human factors on performance. (Chermala et al., 2025).

We will analyze interview and observation data to understand the drivers and barriers of the transformation from a human resources perspective. This will help us explain why the warehouse team has an apathetic mindset and how it influences performance (Purushothaman & Aguas, 2025).

Integration of Quantitative and Qualitative Data, both datasets were integrated during interpretation using a convergent mixed-methods strategy. Quantitative findings demonstrated measurable operational improvements, while qualitative findings explained how organizational and managerial changes contributed to these improvements. This integration enabled development of a comprehensive operational management model.

LITERATURE REVIEW

Cold Chain and Protein Products

The cold chain is defined as a comprehensive logistics system that includes the planning, implementation, and control of product flow from the point of origin to the point of consumption, while maintaining optimal temperatures to preserve quality and extend shelf life (Pagliarini et al., 2025). In the context of food products, especially protein, this system is crucial because products such as meat, fish, and dairy are highly perishable and extremely sensitive to temperature fluctuations (Chermala et al., 2025; Zhao et al., 2025).

Logistics in the cold chain is not limited to transportation; it encompasses the entire process from production, cold storage, and distribution until the product reaches the consumer. The main challenge is ensuring the temperature integrity of the product at every stage, as even a slight deviation can trigger quality degradation, microbial growth, and ultimately a significant loss of product value (Cheng et al., 2024). For example, research on fresh food products shows that optimizing replenishment policies and temperature settings is key to minimizing operational costs and carbon emissions (He & Sun, 2025).

The adoption of advanced technologies such as the Internet of Things (IoT) and Big Data Analytics (BDA) has become an essential element in cold chain transformation (Fatorachian & Pawar, 2024). These technologies allow for real-time monitoring of temperature and humidity throughout the supply chain, providing accurate data to identify potential operational and information risks. (Kim et al., 2025). This data quality is vital as it can be used for more accurate demand forecasting, which ultimately increases efficiency and reduces food loss (Butuc & Akkerman, n.d.; Pigatto et al., 2025). In addition, technologies like blockchain are also being implemented to enhance product traceability, provide transparency from producers to consumers, and strengthen public trust in food quality and safety (Kumar, 2025). In the context of protein products, the challenges become more complex. These products have long production cycles and a high risk of supply chain collapse if the infrastructure is inadequate (Xia et al., 2025). Highly organized warehouse management is needed to overcome issues such as inefficient goods flow and non-ideal product rotation, which are often obstacles (Chermala et al., 2025; Kim et al., 2025). Therefore, a holistic approach that integrates operational management, technology, and sustainability aspects is essential to build a cold supply chain that is not only efficient but also resilient and sustainable (Khalid et al., 2024).

Transforming Warehouse and Supply Chain Operational Management

The transformation of warehouse operational management is a central element of overall supply chain efficiency. This effectiveness highly depends on the ability to manage five key factors: distribution, inventory storage, product quality, demand, and technology (Chermala et al., 2025). Other journals also emphasize that optimal goods flow, such as rethinking stock replenishment policies, is key to minimizing cooling costs and the loss of product value. To achieve this, best practices require a focus on organized warehouse management to ensure perishable products remain fresh and reach consumers on time and without quality degradation. In the digital era, this transformation is supported by the adoption of industry 4.0 technologies, which play a crucial role in improving efficiency and traceability.

1. **Big Data Analytics (BDA):** Data analytics enables firms to identify patterns, predict demand, and optimize inventory (Ma, Wang, & Feng, 2025). This capability enhances supply chain agility, which is important for responding to rapid market dynamics. BDA also helps firms improve organizational resilience through strategic flexibility, which is vital when facing environmental uncertainty.

2. **Blockchain:** This technology offers a solution to enhance product traceability and transparency within the food supply chain. By creating a secure and immutable ledger, blockchain allows all stakeholders to track products from their point of origin to the consumer. Journals show that the adoption of blockchain can improve product quality performance by facilitating better information exchange and collaboration throughout the supply chain.

Despite the substantial benefits, the adoption of this technology is not without risks and challenges, especially for regional-scale cold chains. Research shows that cold chains in developing countries face significant barriers, including financial constraints, a lack of knowledge, and inadequate infrastructure. Digital transformation can also be hindered by climate risks, which cause financial difficulties for firms. Additionally, human (psychological and cultural) barriers can also be a challenge, due to the fear that AI will replace human roles. Therefore, appropriate strategies and strong digital leadership are needed to overcome these barriers and ensure the success of the transformation. Government support and clear regulatory frameworks have also been identified as key factors that encourage the adoption of this technology.

Risk Management and Sustainability

Risk management and resilience are fundamental aspects of cold supply chain management, especially when facing unforeseen external shocks. Food supply chains, in particular, are highly vulnerable to various disruptions, ranging from natural disasters and geopolitical instability to operational failures (Grellmann et al., 2025; Khalid et al., 2024). Developing supply chain resilience allows firms to respond effectively, adapt, and recover quickly from disruptions, thereby minimizing financial and operational losses. (Harwati et al., 2025; Paul et al., 2025). These external shocks, as analyzed in the technological response to natural disasters in developing countries, underscore the importance of a firm's ability to adapt and implement focused response strategies. Alongside risk management, the concept of sustainability has become a strategic priority, encompassing three main pillars: economic, environmental, and social.

1. **Economic Aspect:** Green logistics aims to optimize operational efficiency and profitability while reducing unnecessary costs. Green innovation and investment in sustainable technologies have been proven to enhance a firm's financial performance.
2. **Environmental Aspect:** The main focus of green logistics is to minimize negative impacts on the environment. This includes reducing carbon emissions from transportation and warehouses, improving waste management, and using renewable energy (Fatorachian & Pawar, 2024; He & Sun, 2025). Government policies, such as carbon taxes and incentives, play a crucial role as catalysts in driving the widespread adoption of these practices.
3. **Social Aspect:** Social sustainability includes a commitment to employee well-being, ethical standards, and a positive contribution to society (Kumar, 2025). In the context of the protein cold chain, this relates to ensuring food safety for consumers, which ultimately enhances public trust and supports long-term food security

The integration of best practices in cold storage management is not just about efficiency and profit; it is also about building robust resilience and sustainability throughout the supply chain. A commitment to this sustainability, even through public reporting, has been proven to drive better performance. (Beretta et al., 2025). Therefore, an effective model must combine these three pillars to achieve holistic outcomes.

Supply Chain Performance and Competitive Advantage

Supply chain performance is a key indicator that reflects how effectively a firm manages the flow of goods, information, and finance to achieve its goals (Chermala et al., 2025). Measuring efficiency in the supply chain, especially in the cold chain, requires comprehensive metrics, covering factors such as

distribution, warehouse management, product quality, demand, and technology (Chermala et al., 2025). Some analytical models, such as Data Envelopment Analysis (DEA), are also used to assess technical and scale efficiency, which helps identify the factors that actually affect operational performance after eliminating the influence of the external environment (Ma et al., 2025). A robust performance measurement serves as the foundation for evaluating the effectiveness of every best practice that is implemented.

In a competitive market landscape, innovation is the main driver for firms to achieve a sustainable competitive advantage. Adaptive and strategic innovation is vital, as firms often operate with limited resources. The concept of Hidden Champions describes small to medium-sized firms that become market leaders in their niche through specialization, innovation, and deep collaboration. These firms prove that competitive advantage does not always come from a large scale, but rather from the ability to innovate and collaborate effectively.

One of the most relevant forms of innovation for developing countries is frugal innovation. This concept focuses on creating high-value solutions by using minimal resources. In the cold chain context, frugal innovation can be realized through the use of appropriate technology and smart business models, such as a logistics-sharing model that can significantly reduce costs and carbon emissions. Other journals also show that the adoption of technologies such as IoT and data analytics are key enablers for improving productivity and competitiveness in the agribusiness sector.

Further, research shows that competitive advantage can be realized through non-technical best practices, such as certification and risk management. For example, halal certification has been proven to positively influence the supply chain resilience and financial performance of frozen food SMEs in Indonesia. This confirms that investments in operational practices and certification, which are essentially part of risk management, can be a powerful source of advantage and differentiate a firm from its competitors. Thus, supply chain performance and competitive advantage are inseparable. Accurate performance measurement will be a tool to validate the success of innovations, while innovations focused on efficiency and sustainability will be the main driver for maintaining and expanding a firm's competitive position in the market.

RESULTS AND DISCUSSION

Initial Performance Analysis

Based on historical data and initial observations, we found that the goods flow in the warehouse experienced significant inefficiencies that directly affected productivity and product quality. These problems can be broken down into several key points:

1. **Suboptimal Placement and Layout Planning:** Currently, there is no structured placement plan in each chamber, which causes goods to pile up at one point without an organized entry-exit flow. This condition hinders overall operational efficiency. Organized warehouse management is vital, as it is one of the main factors influencing cold chain performance. (Chermala et al., 2025). An inefficient warehouse layout can also cause unwanted temperature fluctuations, which risk a decline in product quality and loss of product value (Pagliarini et al., 2025; Qi et al., 2024).
2. **Dense Storage Without Maneuver Space:** The stacking of goods too tightly, without leaving adequate maneuver space for retrieval at all points, is an operational challenge that impairs effectiveness. This practice contradicts best practices that emphasize the importance of accessibility to reduce product damage and food loss (Pigatto et al., 2025). The lack of maneuver space can also create logistical bottlenecks that hinder the movement of goods and lead to cost inefficiencies (Kaur et al., 2025).

Figure 1: Dense Storage Condition Without Maneuver Space Before Operational Improvements

3. **Non-Ideal Goods Rotation.** The combination of the problems above results in the physical rotation of goods not following the FIFO (First-In, First-Out) method. This condition makes the warehouse occupancy appear full, but the actual effectiveness is very low. Non-ideal product rotation is one of the main causes of product damage and food loss and waste. To solve this problem, smart optimization is needed to reduce waste and increase a firm's profitability (He & Sun, 2025).
4. **Lack of Traceability.** Goods cannot be quickly counted and tracked. It takes a considerable amount of time to move goods first to ensure a precise check, as access to the physical goods is difficult to reach in certain areas.

Overall, these initial findings indicate an urgent need for a cold storage management transformation. These inefficiencies can be a major obstacle to obtaining certifications such as NKV level-1, which requires strict quality control and supervision throughout the process (Ghafoor et al., 2025).

Figure 2: Initial Warehouse Condition Showing Overcrowded Storage and Blocked Access Points

Goods were stored almost reaching the chamber's ceiling and were placed against the walls, blocking access to the items at the farthest ends.

The image above illustrates the complexity of the supply chain network. The key weaknesses to be addressed include the complexity of distribution routes, inefficient occupancy, ineffective supply-demand connections, unreliable stock accuracy, lack of effective product grouping at strategic locations, and a lack of adequate space and paths for the FIFO (First-In, First-Out) goods flow. The central warehouse also has a very low inventory turnover rate.

Before the operational management improvements, the cold storage warehouse at the Cakung unit functioned as a long-term storage facility with an overloaded capacity. This operational model was characterized by an inefficient goods flow, stacked placement without maneuver space, and non-ideal product rotation, which collectively hindered the warehouse's effectiveness. Conditions like this, especially within the cold supply chain for protein products, can lead to significant operational risks,

such as a decline in product quality due to temperature fluctuations and an increase in food loss and food waste (Chermala et al., 2025; Khalid et al., 2024). Journals that discuss supply chain disruptions in Indonesia also show that product damage is a major problem that occurs due to inadequate infrastructure (Rida Evalina Tarigan et al., n.d.).

Supply Chain Flow before Cold Chain Operational Management Improvements

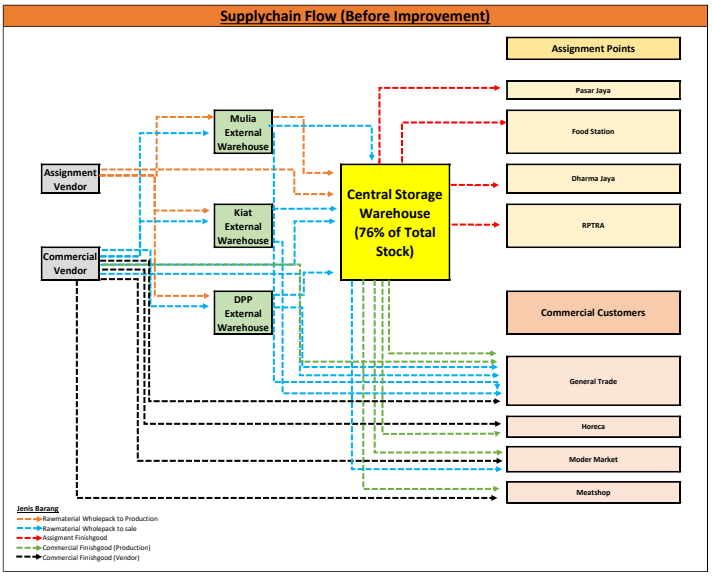

Figure 3: Supply Chain Flow before Cold Chain Operational Management Improvements

Prior to the operational management improvements, the supply chain flow was marked by significant complexity and the fragmentation of production points outside the main warehouse area. This condition caused the movement of raw materials and finished products to be inefficient, less secure, and vulnerable to temperature fluctuations. The movement of goods outside the cold storage area exposed products to ambient temperatures, which directly threatened product quality and cold chain integrity (Li & Kim, 2024; Pagliarini et al., 2025). Journals discussing supply chain disruptions in developing countries also indicate that product damage is a major problem resulting from a lack of integrated infrastructure and management (Rida Evalina Tarigan et al., n.d.).

Goods Movement Flow in Cold Storage Before Operational Management Improvements.

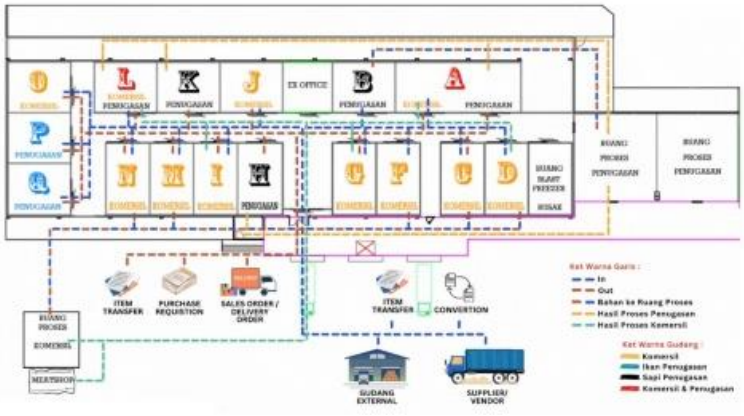

Figure 4: Goods Movement Flow in Cold Storage Before Operational Management Improvements

Identification of Best Practices

The transformation of the central Cakung cold storage warehouse from an overloaded facility to a distribution hub is a strategic step supported by several theoretical frameworks in supply chain management. This change aligns with the principles of modern operational management that prioritize efficiency, resilience, and sustainability (Khalid et al., 2024). The pre-improvement supply chain model, characterized by a complex goods flow and production points separate from the warehouse, reflects operational fragmentation. (Rida Evalina Tarigan et al., n.d.). Supply chain management theory emphasizes that complexity and fragmentation can increase risks and inefficiencies (Kumar, 2025). Other journals also show that an inefficient and unorganized goods flow can hinder overall cold chain performance, including in the aspects of distribution and warehouse management (Chermala et al., 2025).

The improvements were made by centralizing the production process and simplifying the goods flow into a single area. This is a direct example of a supply chain integration strategy. Effective integration, both internally and externally, has been proven to enhance a firm's performance and resilience against disruptions (Aloulou, 2025; Vu & Nguyen, 2025). The shift in the warehouse's focus from long-term storage to a distribution hub with a faster inventory turnover is a key strategy to overcome overloading and improve efficiency. Studies show that optimal warehouse management, including placement planning, is crucial for minimizing food loss and food waste (Kristanto & Kurniawati, 2025; Pigatto et al., 2025). By optimizing the grouping of product categories, traceability can be made easier, and it can ensure that protein products (raw materials and finished products) have an ideal rotation. (Chermala et al., 2025).

The centralization of the production process closer to the warehouse has a crucial impact on product temperature stability. The movement of goods no longer exposed to ambient temperatures directly preserves product quality and reduces the risk of damage, a practice that is highly emphasized in cold chain logistics (Li & Kim, 2024; Qi et al., 2024). This practice is also part of proactive risk management that focuses on disturbance prevention, not just reactive response (Khalid et al., 2024). By improving quality control and better supervision, firms not only maintain quality but also strengthen their position to obtain necessary certifications, such as NKV level-1, which directly contributes to consumer trust and competitive advantage (Ghafoor et al., 2025; Kristanto & Kurniawati, 2025).

Operational management improvements focused on the flow of goods and chamber allocation in the warehouse are strategic steps supported by several theoretical foundations in supply chain management. Cold chain performance is highly dependent on organized warehouse management, including optimal inventory storage, distribution, quality, demand, and technology (Chermala et al., 2025). An inefficient goods flow and unplanned storage allocation can pose various significant operational risks (Khalid et al., 2024). Poor flow, as seen in many supply chains in developing countries, often leads to product damage, food waste, and temperature instability, which in turn hinders efficiency (Mo & Song, 2025; Rida Evalina Tarigan et al., n.d.). Therefore, optimizing warehouse layout and resource allocation is crucial for minimizing costs and environmental impact, a concept that is quantitatively evaluated in logistics efficiency studies (Li & Kim, 2024).

Thus, the operational management improvements that have been implemented, such as planning for goods flow and chamber allocation, are a direct implementation of best practices aimed at creating a more efficient and resilient cold chain. Scientific journals have shown that technological innovation and structured operational management can be key drivers for an efficient and sustainable cold chain logistics model (Chermala et al., 2025; Fatorachian & Pawar, 2024). This optimization not only improves internal performance but also enhances product traceability, which is supported by blockchain technology to ensure food quality and safety from upstream to downstream (Gangwani & Bhatia, 2025).

These strategic steps are not only aimed at efficiency but also at risk mitigation. By improving goods flow and allocation, the risk of temperature fluctuations can be controlled, which is a best practice in maintaining the quality of protein products (Pagliarini et al., 2025). Proactive risk management, which focuses on disturbance prevention through better operational practices, has been proven to be more effective in building long-term supply chain resilience (Khalid et al., 2024).

Model Development

In accordance with relevant literature-based best practices, a strategic transformation was carried out by changing the function of the Cakung cold storage unit from a primary storage facility into a distribution center. This change marks a shift from a passive model, which was oriented towards long-term storage, to an active model that focuses on efficiency and a faster inventory turnover. In this new model, the warehouse is positioned to manage goods ready for short-term distribution or raw materials ready for production. This strategy aligns with modern operational management concepts that emphasize optimization and appropriate strategies (Kim et al., 2025). Other journals also show that digital transformation and Industry 4.0 technologies can be key drivers for an efficient last-mile delivery model, which is a core function of a distribution center (Sharma et al., 2025).

After Cold Chain Operational Management Improvements

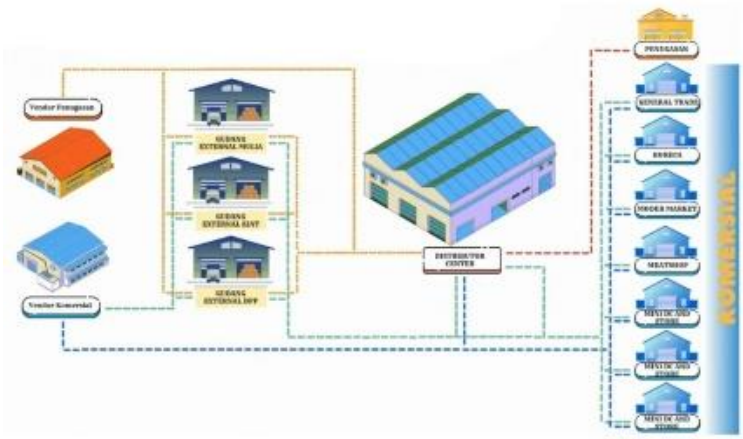

Figure 5: Supply Chain Flow Diagram After Cold Chain Operational Management Improvements

The impact of this transformation is very visible in the significantly faster inventory turnover. With improved flow and placement, the physical rotation of goods can now follow the FIFO (First-In, First-Out) principle more consistently. This optimization not only increases the efficiency of warehouse space utilization but also has a positive impact on reducing food loss and waste (He & Sun, 2025; Pigatto et al., 2025). Better cold storage management and faster turnover directly affect product quality and ultimately facilitate the achievement of certification standards, such as NKV level-1, which is proof of a commitment to quality control and food safety (Ghafoor et al., 2025; Kristanto & Kurniawati, 2025).

The process of centralizing production and simplifying the flow of goods in the Cakung cold storage unit shifts the main warehouse's function from static storage to a distribution center with a much faster inventory turnover. The primary focus of these improvements is the optimization of operational management within the warehouse, especially concerning the grouping of product categories, goods flow, and movement paths. The goal is to facilitate product traceability, improve the flow of goods inside the cold storage, and centralize the movement of raw materials and finished products in the main warehouse area. This strategy aligns with the concept of best practices that emphasize specialization and deep collaboration to achieve competitive advantage (Zhao et al., 2025).

Flow of Goods Movement in Cold Storage After Operational Management Improvements.

The impact of this transformation is highly significant for improving efficiency and sustainability. With centralization and improved flow, the anteroom temperature becomes more stable, which directly affects the maintenance of product temperature and quality. This condition allows for earlier risk mitigation, reducing the supply chain's vulnerability to internal and external shocks (Khalid et al., 2024). The safety of goods is also better maintained because product movement is now limited to within the warehouse area, no longer exposed to ambient temperatures. This optimization not only increases

productivity but also effectively reduces food loss and waste (He & Sun, 2025; Pigatto et al., 2025), a crucial step in supporting food security in Jakarta.

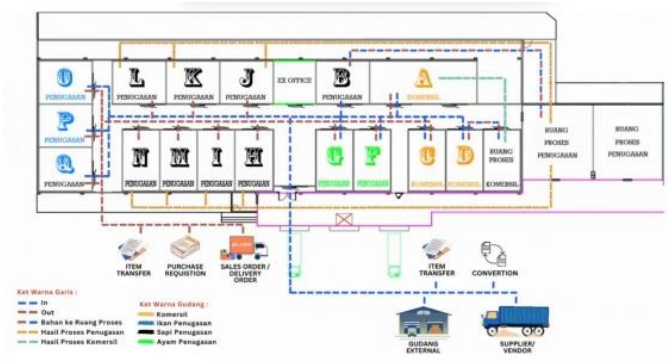

Figure 6: Goods Movement Flow in Cold Storage After Operational Management Improvements

DISCUSSION

Discussion: Comparison of Findings with Literature and the Regional-Scale Cold Chain Context

The findings from the operational management transformation at the Cakung cold storage unit provide strong empirical evidence for the success of best practices in the context of Jakarta's cold chain. The strategic shift from an overloaded storage warehouse to an efficient distribution hub aligns with several theoretical foundations.

First, the centralization of the production process and the simplification of goods flow represent an implementation of the supply chain integration strategy that has been proven to improve a firm's performance and resilience against disruptions. By moving the production point closer to the storage area, the firm successfully unified previously fragmented activities, which according to the literature can reduce complexity and operational risks. (Kumar, 2025; Mo & Song, 2025).

Second, the improvement in goods flow and chamber allocation directly addresses the inefficiency problems often faced by supply chains in developing countries. The initial warehouse condition, which was stacked without maneuver space and had non-ideal goods rotation, as you stated, is a major cause of food loss and food waste. These findings are consistent with research that shows optimal warehouse management and cost-saving strategies, such as optimizing space utilization, are crucial for improving efficiency and profitability.

Third, the most crucial impact of this transformation is the control of product temperature and quality. The movement of products no longer exposed to ambient temperatures is a form of proactive risk management that focuses on disturbance prevention, not just a reactive response. This strategy aligns with findings from other cold chain studies that highlight that strict quality control and supervision are key to maintaining the integrity of perishable products and meeting certification standards.

From all these conclusive aspects, the implementation of this operational management has gained recognition with NKV Level-1 certification (No. CS 317506-059), with zero major and minor deviations. While this model has proven successful, its application in regional-scale and developing country contexts still faces challenges. One of the main challenges is the apathetic mindset of the warehouse team due to unresolved, long-standing issues. This is supported by literature that identifies human barriers (cognitive biases) and organizational culture as critical factors in the adoption of new practices. Other research also shows that digital leadership and collaborative management are essential to overcome resistance to change and drive sustainable transformation at a regional level.

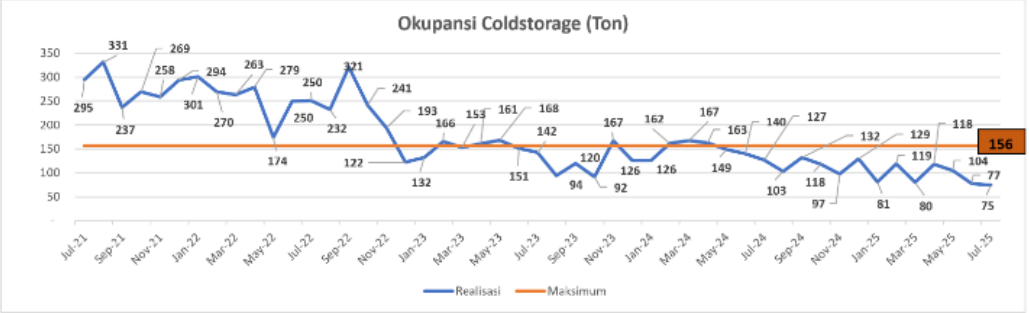

Figure 7: Cold Storage Occupancy Trend Before and After Operational Management Improvements

Occupancy Optimization and Its Impact on Operational Efficiency

Strategic adjustments in cold storage operational management have led to significant changes, particularly in optimizing the average warehouse occupancy. The warehouse, which previously operated far above its ideal capacity (overloaded), has now been successfully normalized. This prior overloaded condition theoretically increased operational risks and supply chain vulnerability, as it hindered the efficient flow of goods and complicated quality control.

The normalization of occupancy has a direct impact on improved operational efficiency and productivity. The goods flow within the warehouse has become more organized and planned, with each product grouped according to its category. Organized warehouse management, including strategic inventory placement, is a key factor influencing cold chain performance (Chermala et al., 2025). With a better flow, access to goods at all points in the warehouse becomes easier, which directly accelerates inventory turnover. This faster turnover is crucial in the context of protein products, as it effectively reduces food loss and waste.

In addition to improving efficiency, these enhancements also have a positive impact on Occupational Health and Safety (OHS). The organized flow and placement reduce the risk of workplace accidents, aligning with best practices that emphasize strict supervision and quality control for risk mitigation (Ghafoor et al., 2025). The increase in efficiency also allows the First-In, First-Out (FIFO) system to operate optimally, which is a fundamental practice for maintaining product quality and ensuring compliance with food safety standards.

Figure 8: Comparison of Warehouse Conditions Before and After Transformation

Overall, the adjustment of warehouse occupancy and the implementation of a more structured operational management demonstrate that a transformation focused on optimizing existing resources can lead to significant and holistic performance improvements, covering aspects of efficiency, sustainability, and safety.

Data Collection Method: In-depth Interviews and Scoring System

Data was collected through in-depth interviews with 11 people in the Warehouse department, consisting of various hierarchical levels, from staff and employees to supervisors and department heads. This approach ensures that the collected data reflects perspectives from various levels within the organization. The interviews were designed to explore the narrative before and after the operational improvements, which is an effective method for identifying and understanding the phenomenon of transformation.

To measure the perceived impact, every operational aspect discussed in the interviews was assessed using a scale of 1 to 10. This method, which is a form of qualitative data quantification, allows for the conversion of subjective perceptions (such as ease and neatness) into numerical data that can be analyzed. This scoring system helped the researchers identify measurable changes in cold chain efficiency and performance, which is the main objective of this study.

Scientific Principles in Interviews and Assessment

The aspects assessed in the interviews are directly related to relevant supply chain performance metrics, such as:

1. **Operational Efficiency:** The ease of goods movement, administrative neatness, organized goods flow, and a well-functioning FIFO rotation are all key indicators of effective warehouse and logistics management (Chermala et al., 2025). Improved operational efficiency not only saves costs but also increases overall productivity.
2. **Risk and Quality Management:** The assessment of temperature conditions in the anteroom and chamber is a critical metric in cold chain management, which directly affects product quality and food safety. Good risk management is also reflected in an organized flow, which reduces product exposure to temperature fluctuations. (Khalid et al., 2024).
3. **Traceability:** The ease of tracing goods is a vital aspect of digital transformation and supply chain integration. Journals show that the ability to accurately and quickly track products is key to improving quality and consumer trust, and this can be achieved through integrated information technology. (Gangwani & Bhatia, 2025).

The collected data, both the narratives from interviews and the assessment scores, will be analyzed descriptively and comparatively. The comparison of the average scores from the conditions before and after the improvements will provide a quantitative overview of the impact experienced by the team. These results will then be validated and enriched with qualitative narratives from the interviews, which will explain the "why" and "how" of these changes in influencing the team's real-world mindset and productivity.

Table 1: Assessment of Temperature, Cleanliness, and Room Conditions Before and After Improvements

Sample	Warehouse Development	Condition Before Operational Management Improvement	Condition After Operational Management Improvements	Extent of Improvement	Anteroom Temperature before Operational Management Improven	Cleanliness before Operational Management Improvement	Anteroom Temperature after Operational Management Improvements	Cleanliness after Operational Management Improvements
1	9	8	9	9	3	7	10	9
2	10	1	10	10	1	1	10	10
3	10	5	8	10	5	5	10	10
4	8,5	6	8,5	8	5	5	9	10

Sample	Warehouse Development	Condition Before Operational Management Improvement	Condition After Operational Management Improvements	Extent of Improvement	Anteroom Temperature before Operational Management Improvemen	Cleanliness before Operational Management Improvement	Anteroom Temperature after Operational Management Improvements	Cleanliness after Operational Management Improvements
5	9	6,5	10	10	7	6	10	9,5
6	8	6,5	8,5	8,5	5	6,5	8	8,5
7	9	4	9	8	5	4	9	10
8	9	7	10	9	4	4	8	8
9	9	4	9	9	3	6	9	8
10	9	7	9	9	6	7	9	9
11	9	6	9	9	6	7	9	9
Average Score	9,045	5,545	9,091	9,045	4,545	5,318	9,182	9,182

Table 2: Assessment of Layout, Maneuverability, and Administrative Order Before and After Improvements

Sample	Chamber Temperature before Operational Management Improvements	Cleanliness before Operational Management Improvements	Chamber Temperature after Operational Management Improvements	Cleanliness after Operational Management Improvements	Administrative Tidiness before Operational Management Improvements	Maneuverability or Movement of Goods before Operational Management Improvements	Administrative Tidiness after Operational Management Improvements	Maneuverability or Movement of Goods after Operational Management Improvements
1	5	3	9	9	1	3	10	9
2	5	5	10	10	5	1	10	10
3	5	5	10	10	5	6	10	9
4	6	5	10	9	5	6	9	10
5	4	5	10	10	1	5	10	10
6	6,5	6,5	8,5	8	7	6,5	8	8,5
7	6	4	10	9	5	5	9	8
8	5	6	8	9	2	3	8	7
9	4	3	10	8	3	3	7	9
10	9	6	9	9	7	6	8	9
11	8	5	9	9	7	5	8	9
Average Score	5,773	4,864	9,409	9,091	4,364	4,500	8,818	8,955

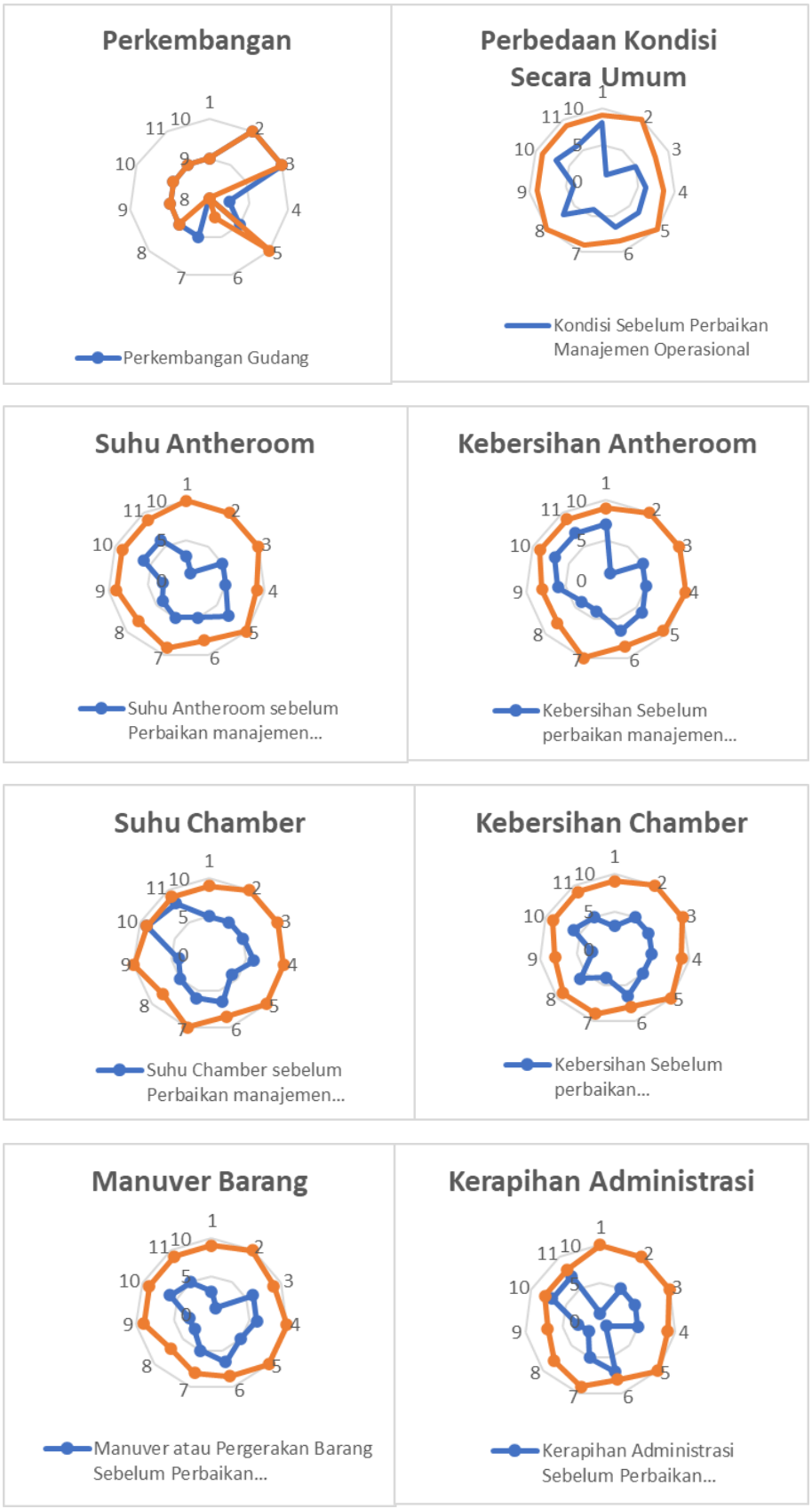

Figure 9: Comparative Chart of Operational Aspect Scores Before and After Improvements

Initial Performance Analysis: Measurable Impact of Warehouse Operational Transformation

This study used a mixed-method approach with qualitative data quantification to measure the impact of cold storage operational management improvements. The scores given by 11 respondents, ranging from staff to department heads, show a significant increase across all aspects of warehouse performance. The visual data from the attached bar charts clearly illustrate the success of this transformation, where the initial average score of 2.125, which symbolized inefficiency and acute constraints, sharply rose to 9.125 after the improvements were implemented. This score increase of 7.00 provides strong empirical evidence of the success of the implemented management.

1. Increased Efficiency and Operational Management

The significant increase in the scores for Goods Movement (1.00 to 9.00), Goods Flow (1.00 to 9.00), and Goods Grouping (1.00 to 9.00) confirms that structured operational management can overcome the inefficiencies arising from disorganized placement. The scores for movement had the highest increase, a change that can be attributed to a comprehensive rearrangement model, with a main focus on the ease of goods movement and transparency. These findings align with literature that identifies warehouse management and inventory storage as a fundamental factor in cold chain performance (Chermala et al., 2025). This improvement shows that the changes successfully transformed the warehouse from an overloaded to an optimal condition, which is a strategic step to increase efficiency and productivity.

2. Quality, Cold Chain Integrity, and Traceability

The scores for Anteroom Temperature (2.00 to 8.00) and Chamber Temperature (2.00 to 9.00) are proof that the transformation successfully maintained temperature stability. Effective cold chain management is key to preserving the quality of perishable protein products, and temperature stability is its primary prerequisite (Pagliarini et al., 2025). The score for Kemudahan Tracing Ease of Tracing, which surged from 1.00 to 9.00, also provides evidence that the implemented best practices have improved product traceability. This traceability, often supported by digital transformation, is crucial for food safety and consumer trust , and can be achieved through integrated information technology. (Kumar, 2025).

3. Team Safety and Well-being

The significant increase in the scores for Administrative Tidiness (3.00 to 9.00) and Occupational Health and Safety (OHS) (2.00 to 8.00) shows the positive impact of the transformation on non-operational aspects. A tidier and safer work environment directly correlates with team morale and productivity, which can transform an apathetic mindset into a proactive one. These findings support literature that highlights organizational culture and collaborative management as key factors in the success of a transformation, proving that improvements are not only procedural but also have a strong social and human impact.

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