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KHO THỦY SẢN LẠNH: BÀI HỌC TỪ THÁI LAN VÀ KIẾN NGHỊ CHO DOANH NGHIỆP VIỆT NAM

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Tóm tắt

Cùng với sự phát triển và hội nhập kinh tế quốc tế, đặc biệt là sau các sự kiện ký kết hiệp định với những nước phát triển, ngành thủy sản hiện nay là một trong những ngành kinh tế giữ vai trò quan trọng trong sự phát triển của nền kinh tế Việt Nam với lợi nhuận cao và có rất nhiều lợi thế về thương mại để xuất khẩu ra các thị trường trên thế giới. Tuy tăng mạnh, nhưng sản lượng xuất khẩu hải sản của các doanh nghiệp Việt Nam ra thế giới vẫn chưa tương xứng với năng lực sản xuất ở trong nước. Theo các chuyên gia, nguyên nhân chính là do hoạt động bảo quản lưu kho hàng hóa trong chuỗi cung ứng lạnh còn yếu, dẫn đến chất lượng sản phẩm chưa đáp ứng được các tiêu chuẩn của nước ngoài. Trong khi đó, Thái Lan đã nghiên cứu và ứng dụng nhiều công nghệ hiện đại trong hệ thống kho lạnh lưu trữ hải sản và đã được các nước trên thế giới sử dụng rộng rãi, đồng thời hệ thống kho lạnh của Thái Lan cũng nhận được sự hỗ trợ từ các hiệp hội trong nước và sự đầu tư lớn mạnh của các doanh nghiệp. Vì vậy, bài nghiên cứu này nhằm mục tiêu tìm hiểu những kinh nghiệm của Thái Lan trong phát triển hệ thống kho lạnh hải sản, đồng thời đưa ra những đánh giá về thực trạng của Việt Nam trong ngành này từ việc phân tích những số liệu từ các bài báo đã có sẵn, qua đó đề xuất những giải pháp dành cho các doanh nghiệp xuất khẩu hải sản của Việt Nam nhằm cải thiện sản lượng và chất lượng sản phẩm.

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REFRIGERATED WAREHOUSE OF SEAFOOD: LESSONS FROM THAILAND AND RECOMMENDATIONS FOR VIETNAMESE ENTERPRISES

Abstract

Along with development and international economic integration, particularly after the signing of agreements with developed countries, the seafood industry is now one of the economic sectors in Vietnam that plays an important role in the country's economy, with high profits and many commercial advantages for exporting to global markets. Despite a significant increase, the exporting seafood output of Vietnamese enterprises remains weak compared to the domestic production capacity. According to experts, the fundamental cause is that the cold supply chain's preservation and storage of seafood products is still inadequate, resulting in product quality that does not satisfy foreign standards. Meanwhile, Thailand has researched and applied modern technologies in refrigerated storage systems for seafood and has been widely used by countries around the world. At the same time, Thai refrigerated storage system also receives support domestic associations and investment. This research aims to comprehend Thailand's experiences in developing a seafood refrigerated warehouse system while also providing assessments of Vietnam's current condition in this industry from analyzing data from available articles. Then, drawing on Thailand's experience, provide recommendations for Vietnamese seafood enterprises to improve the refrigerated storage infrastructure.

Keywords: refrigerated warehouse, seafood, Thailand, Vietnam

1. Introduction

In the ever-evolving landscape of international trade and commerce, the seafood industry serves as a remarkable example of the intricate interplay between the creation, preservation, and distribution of its products. This industry transcends its culinary allure; it embodies a commitment to sustainability, the protection of marine ecosystems, and the provision of essential nutrition to countless people worldwide.

In a world characterized by the relentless march of globalization and the ever-expanding frontiers of global trade, the seafood sector assumes a pivotal role within the vast supply chain. Ensuring the immaculate preservation of seafood products during their journey from source to destination presents a formidable challenge that demands meticulous planning and the development of robust infrastructure. At the heart of this challenge lies the critical role of refrigerated warehouses within the broader cold supply chain process.

Drawing inspiration from Thailand's notable achievements in the realm of seafood cold chain management, our group has selected the compelling topic of "Refrigerated Warehouse of Seafood: Lessons from Thailand and Recommendations for Vietnam". This endeavor seeks to unearth invaluable insights gleaned from Thailand's wealth of experience in refrigerated warehouse

management and, in turn, to provide strategic recommendations meticulously tailored to address the distinctive hurdles and prospects encountered by Vietnam's seafood enterprises.

The report is structured into four main parts as follows:

Theoretical framework

Analysis of refrigerated warehouse of Thai seafood

Analysis of refrigerated warehouse of Seafood in Vietnam

Recommendations for the refrigerated warehouse of Vietnamese enterprises

2. Theoretical framework

2.1. Cold supply chain management

A cold chain is a series of processes that involve the storage, handling, and transportation of perishable items. These processes require controlled temperature environments to ensure the safety and quality of products from the moment they are harvested until they reach consumers (Hundy, Trott, & Welch, 2008). Specifically, within the realm of the food industry, the cold chain refers to the stages between harvesting or slaughtering and the point of purchase by consumers (Wang & Yip, 2018).

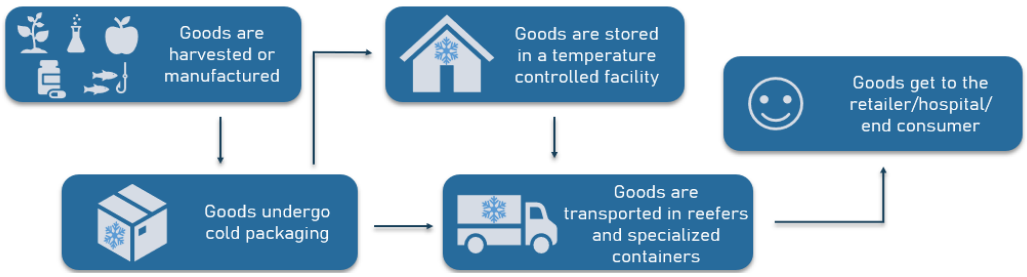

Figure 1. Cold chain logistics process.

Source: Altexsoft.

Developed nations rely heavily on the cold chain, which handles more than 90% of fruits, vegetables, and virtually all meat and poultry products (Yuan et al., 2015). Although developing countries currently have limited cold chain coverage, it is rapidly expanding, particularly in India and China (Salin, 2018). Research by (James & James, 2010) indicates that inadequate cold chain facilities lead to the loss of over 200 million tons of perishable food in developing countries. Consequently, the growth of the cold chain industry is crucial. The global demand for refrigerated foods has driven the expansion of cold chain services.

Cold chain management goes beyond the typical supply chain objectives of cost reduction and responsiveness. It must also address concerns related to product quality and environmental impact (Beh-dani, Fan, & Bloemhof, 2019). Furthermore, changing consumer preferences and the emergence of e-commerce as a significant purchasing channel have introduced new challenges, particularly in delivering highly perishable goods. Thus, effective cold chain management must

focus on maintaining the quality of perishable items, considering factors such as microbiological, physiological, biochemical, and physical processes that occur throughout the chain (James & James, 2010).

2.2. Refrigerated warehouse of cold supply chain

A cold storage warehouse is a storage facility constructed with precise climatic conditions in mind to keep items safe at suitable temperatures. These warehouses usually look like any other warehouse from the outside, but differ in their internal environment. As outlined by Wang & Yip (2018), refrigerated storage, often referred to as cold storage, involves the preservation of temperature-sensitive goods within specialized facilities maintained at specific low temperatures. These storage sites are equipped with cooling systems and insulation to create an environment that retards product degradation, safeguarding quality until distribution readiness.

Throughout the journey from production to consumer, all chilled and frozen products undergo storage in cold stores at least once. Chilled storage rooms maintain temperatures between -1 and 12°C, while frozen storage rooms maintain temperatures below -18°C. The cold storage market displays a wide spectrum, ranging from small storage units of 10-20 m3 to expansive warehouses with hundreds of thousands of cubic meters.

Global refrigerated warehouse capacity reached 616 million cubic meters in 2018, indicating a 2.67% increase from 2016. India led with 150 million cubic meters, trailed by the United States at 131 million cubic meters, and China at 105 million cubic meters. In developing nations, the demand for refrigerated and frozen foods, driven by the middle-class and high-income segments, fuels the refrigerated warehouse service industry.

The ongoing Russia-Ukraine conflict has had a medium-term impact on global economic recovery, leading to economic sanctions, increased commodity prices, supply chain disruptions, inflation, and market challenges worldwide. However, according to Savills Industrials, the cold storage market is anticipated to continue expanding at a CAGR of 17.0%, reaching $303.22 billion by 2027.

According to Fiingroup's recent report, Vietnam's cold chain market has witnessed strong growth, marked by a 25.2% increase in cold storage facility capacity and a growing fleet of cold transportation providers between 2020 and 2022. This growth has been driven by rising demand for cold storage and transportation services, primarily due to increased exports in the seafood sector.

2.3. Refrigerated warehouse in seafood industry

Seafood presents a significant challenge due to its perishable nature, as its quality deteriorates over time, leading to decomposition. To counteract these chemical reactions and ensure that this delicate raw material remains undamaged and safe throughout its journey from the ocean to the consumer, it is imperative to maintain consistently low temperatures and implement a robust cold chain process.

A refrigerated warehouse within the seafood industry serves as a specialized storage facility designed to uphold low temperatures, which are crucial for maintaining the freshness and quality of seafood products. These warehouses have designated areas with precise temperature controls, typically ranging from -18°C to 4°C (0°F to 39°F). These temperature ranges are vital for slowing down the growth of bacteria and preventing the spoilage of seafood items. The storage capacity of these facilities can vary based on their size and intended purpose.

In order to maintain a dependable cold chain process, cold storage facilities utilize advanced refrigeration systems to precisely control temperature and humidity levels, thereby preserving seafood under optimal conditions. This process extends the shelf life of fish, prevents the proliferation of harmful bacteria, and retains the nutritional value of the seafood. Additionally, it allows seafood processing plants to store their raw catches for extended durations, ensuring a steady supply throughout the year and reducing reliance on seasonal availability. Furthermore, these facilities are equipped to store various types of seafood, including prawns, squid, and various fish species, supporting their processing, wholesale distribution, and retail value chain operations in many developing countries.

3. Analysis of refrigerated warehouse of Thai seafood

3.1. Current situation of Thailand's refrigerated warehouse

The cold chain industry in Thailand has seen robust growth due to its global reputation as a food hub, and a boosted demand for frozen ready-to-cook meals among Thai consumers (Geeta, 2023). Hence, expanding cold storage capacity and implementing advanced technologies are significantly invested by both the government and businesses.

3.1.1. General indications (location, capacity, suppliers)

In 2022, the total number of refrigerated warehouses containing seafood storage in Thailand is 124. The total capacity of both public and private warehouses for seafood storage in Thailand was approximately 2.69 million metric tons, as shown in Table below.

Table 1. The number and capacity of Refrigerated Warehouse of Thailand in 2022

Region	Number	Capacity (metric tons)
Central	95	2,173,376.69
Eastern	4	21,568.22
Northern	6	47,589.52
North-eastern	5	27,988.19
Southern	14	416,288.50

Total	**124**	**2,686,811.12**

Source: Thailand's Department of Internal Trade

The majority of refrigerated warehouses dedicated to seafood storage, over 80%, are located in central Thailand. As being an ideal location for seafood production and distribution, it is required numerous cold storage facilities and reliable chilled/frozen transport services In contrast, the northern, northeastern, and eastern regions have fewer warehouses due to their mountainous terrain, leading them to primarily focus on vegetables and fruit products rather than seafood (Ongkittikul, S. et al, 2019).

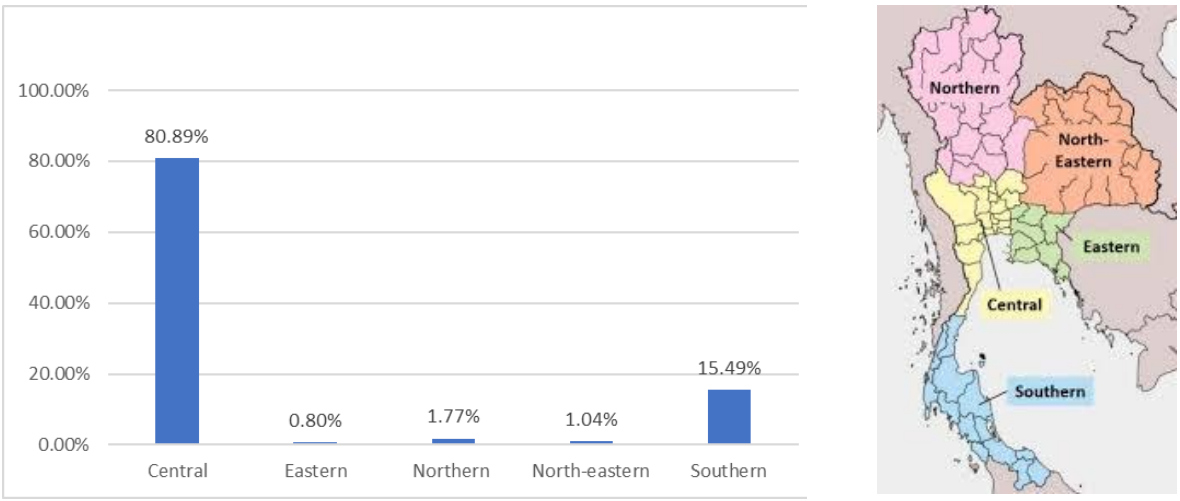

Figure 2. The Capacity of Cold Warehouse containing seafood in Thailand by Region

Source: *Thailand's Department of Internal Trade*

According to Thailand's department of business development, the data as of October 3 2023 shows that there are 217 active companies providing refrigerated warehouses for chilled/frozen products. The number of companies offering cold storage facilities increased by 11.34% compared to the end of 2022 and the amount of capital increased by 11.14% from the previous year. In addition, of these, 5% of the total are major players such as JWD infologistics, Thai Yokorei Co Ltd., and Sinchai Cold Storage, with the majority being a part of bigger business networks that have been engaged in the production and processing of fruits, vegetables, dairy goods, meat, and seafood. The other 95%, were SMEs (Piyanuch Sathapongpakdee, 2022).

3.1.2. Warehouse management and distribution

To optimize the warehouse space and maximize storage capacity with diverse kinds of seafood, Thai refrigerated warehouses manage and distribute storage facilities as follows. In the general warehouse, different areas with different technical specifications and various machinery are allocated to serve different purposes for storing different types of goods. Typically, the rooms are classified by temperature.

Air Blast Freezer Room, temperature -35°C

Air blast freezer rooms at -35°C are ideal for the seafood industry, preventing cell damage during rapid cooling. This 2.5-ton capacity room freezes seafood in 4-5 hours while crucially maintaining -35°C for up to 6 hours. Methods include Forced Air Freezer, Brine Freezer, and IQF. The Cell Alive System (CAS) preserves seafood's quality and cellular structure for extended periods, crucial for exports.

Freezer Room, temperature -5°C to -25°C

This type of room is ideal for long-term product storage, especially for seafood with freezing point temperatures. For instance, frozen fish can be stored at temperatures between -17.8 to -23.3 degrees Celsius for extended periods, typically around 8 to 10 months. The required operating temperatures typically fall within the range of -5 to -25 degrees Celsius, depending on the specific product.

Cold Storage Room, temperature -25°C

This type of room is designed for storing seafood that are already frozen. They will have temperatures that are either "equal to" or "lower than" the temperature of the storage room. When calculating the cooling load, there's no need to factor in the heat value from the product. Typically, the required operating temperature is around -25 degrees Celsius or varies based on the specific product.

3.1.3. Technology for managing warehouse

To effectively operate and monitor the cold storage, Thailand’s refrigerated warehouses have applied several systems and softwares, as following:

The systems, applications, and products (SAP) system and the Warehouse Management Software (WMS)

The systems, applications, and products (SAP) system and the Warehouse Management Software (WMS) program are the major technologies employed by Thailand’s food business to manage goods. These systems are designed to empower the organization with comprehensive control over various aspects of its business operations, encompassing inventory, production, financial, and related functions. In addition to the SAP, the internal organization is also capable of sharing relevant information. Similarly, the WMS enables users to efficiently manage stocks and is compatible with a barcode system (Ongkittikul,S. et al, 2019).

Automated storage and retrieval system (ASRS)

An Automated Storage and Retrieval System (ASRS) is a computer-controlled solution used in warehouses and distribution centers for efficient item storage and retrieval. It combines hardware and software to optimize inventory management, reducing operational time and labor. ASRS ensures items are stored based on their movement speed, prevents merchandise damage, controls environmental factors, and enhances security. It prioritizes order processing using a FIFO

approach, managing aging merchandise and warehouse space. ASRS also performs accurate stock counts by brand and stock code, aiding inventory management, procurement, and lead time reduction. However, due to infrastructure and staffing requirements, ASRS is typically used by larger companies like JWD Infologistics.

3.1.4. Thailand's developing implementation for seafood cold chain management

Warehouse, silo, and cold storage policy

The Market System Promotion and Administration Division, under the Department of Internal Trade within the Ministry of Commerce, is responsible for overseeing the Warehouse, Silo, and Cold Storage Act of 2015. This act guides the division in establishing regulations for such facilities and involves researching, analyzing, and providing guidance to entrepreneurs to meet these regulations, reducing wastage costs and enhancing competitiveness. The division's duties also include issuing and revoking operation licenses and supervising warehouse, silo, and cold storage businesses to ensure compliance with the law. As of 2019, there are over 100 certified operators adhering to these standards, with about 75% of them being Thai small and medium-sized enterprises (SMEs) (Ongkittikul, S. et al, 2019).

The Warehouse, Silo, and Cold Storage Association

The Warehouse, Silo, and Cold Storage Association is a non-governmental organization established in 2008 and officially recognized under the Trade Association Act (1966) with support from the Department of Internal Trade, aims to promote, endorse and advance the warehouse, silo, and cold storage industry. As of 2019, the association's membership includes roughly 50% of all registered businesses operating within these sectors, primarily SMEs. The association plays a pivotal role in advocating for industry interests during policy-making and fosters networking between smaller and larger enterprises.

The developing investments of Thai enterprises in seafood refrigerated warehouses

According to Ken Research, the Thailand Cold Chain Market is projected to surpass THB 20 billion by 2026, driving increased investments in cold storage facilities by businesses involved in seafood, meat, and fruit production and export. Rental cold warehouse companies are also expanding capacity and technology to meet rising demand.

A remarkable example is the partnership between Thai Union Manufacturing Co., Ltd. (TUM) and JWD InfoLogistics Public Company Limited, which led to the joint venture of Pacific TUM Cold Storage Co., Ltd. (PACT). PACT is constructing a cold storage warehouse to support TUM's growing raw material supply needs.

Thai Union is a global leader in the seafood industry, while JWD InfoLogistics is Thailand's top cold storage facility provider, offering the first free zone cold storage and public ASRS warehouse, primarily for seafood products. Shiraphong Chansiri, CEO at Thai Union Group shared that this joint venture aims to strengthen seafood supply chain management, enhance

competitiveness, and generate profits for both companies, recognizing the growth potential in the industry.

3.2. Achievements of Thailand's refrigerated warehouse for seafood

Firstly, the effectiveness of refrigerated warehouses for seafood accelerates export activities in Thailand.

Thailand's seafood industry has changed dramatically during the last 30 years. It has not only become a profitable exporting sector, but it has also risen up the global value chain. Thailand, which used to export unprocessed or semi-processed seafood, now exports high-value-added processed frozen seafood in a variety of recipes. As the second-largest exporter in ASEAN, it plays a vital role in the region's expanding supply chain, particularly in satisfying increased demand for cross-border logistics services (ITA 2018). By applying advanced technology, refrigerated warehouses significantly boost Thailand's seafood export activities by ensuring product quality, extending shelf life, diversifying markets, and complying with regulations. The systems, applications, and products (SAP) system and the Warehouse Management Software (WMS) by Thai enterprises enable year-round supply, add value through processing, reduce transportation costs, enhance traceability, and contribute to economic growth, ultimately making Thai seafood more competitive and appealing in global markets.

Table 2. Canned, Prepared & Preserverved seafood Exports, by Country

By Volume (Tonnes, k)	2006	2011	2016	2021	
				Value	% Share
1. China	21.6	20.8	21.8	1,495.0	27.8
2. Thailand	**19.7**	**23.3**	**17.8**	**752.6**	**14.0**
3. Ecuador	4.9	5.0	5.4	325.2	6.1
4. Spain	2.9	3.6	3.8	225.4	4.2
5. Morocco	3.5	2.7	3.7	189.8	3.5
Others	47.4	44.6	47.5	2,381.4	44.4
Total	**100.0**	**100.0**	**100.0**	**5,369.4**	**100.0**

By Value (USD, m)	2006	2011	2016	2021	
				Value	% Share
1. China	24.6	23.7	25.0	10,028.3	29.3
2. Thailand	**17.5**	**20.0**	**14.2**	**3,435.8**	**10.0**
3. Vietnam	2.3	4.6	7.4	2,461.0	7.2
4. Indonesia	1.9	2.9	3.8	1,555.3	4.5
5. Spain	3.4	3.6	3.4	1,339.6	3.9
Others	50.3	45.2	46.2	15,416.0	45.1
Total	**100.0**	**100.0**	**100.0**	**34,236.0**	**100.0**

Source: Trade Map

According to The Nation news, Thailand exported fresh, chilled, frozen, canned, and processed seafood (including canned and processed tuna but excluding fresh, chilled, frozen, and processed shrimp) totaling 9,480.46 million baht in January 2021. The United States, Japan, Australia, Egypt, and Canada accounted for 57.37% of all frozen food imports from Thailand. Canned tuna; processed fish (tuna + other fish); canned shrimp; other canned seafood; live, chilled, and frozen squid are the nearly Thai frozen food products with the largest export value in 2020.

In 2022, the canned seafood market remained the most profitable of all segments of the Thai processed seafood business. Exports increased by 4.1% to 617,500 tonnes, generating USD 2.8 billion in revenue (+13.0%) (Krungsri, 2023).

This achievement is supported by an increasingly robust a cohesive sectoral innovation system. Large corporations have improved their technical capacities. Many of these companies have their own R&D divisions for product development. Some SMEs have enhanced their capacities as well. There are universities and public research organizations that provide seafood-specific teaching and research programs. Their partnerships with companies, particularly major corporations, have become stronger through a variety of channels, including cooperative and collaborative R&D, licensing, training, consulting, and technical services.

Secondly, the effectiveness of refrigerated warehouses for seafood promotes domestic seafood industry in Thailand.

Due to increased seafood and meat consumption in Thailand, the frozen seafood and meat category will dominate the frozen foods market in 2022. Thailand's frozen food sector is quickly expanding and has been named one of the "most promising industries in 2023" by the Thai Ministry of Commerce. In 2022, 99 new firms were registered in Thailand's frozen food sector, representing an 87% year-on-year increase, bringing the overall number of frozen food companies to 838, with around 90% being small businesses (PR Newswire, 2023).

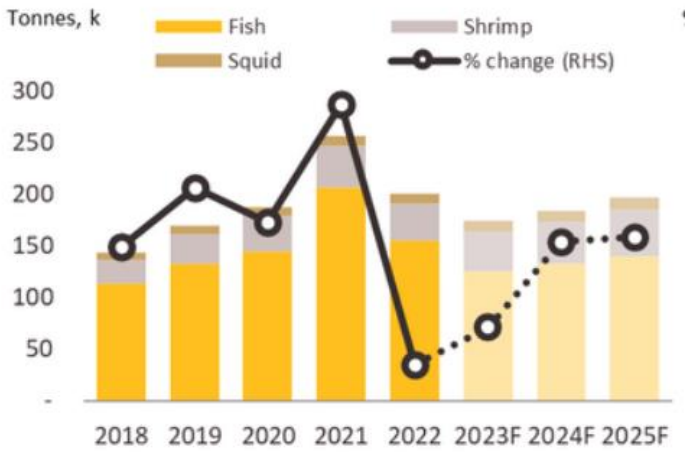

Figure 3. Domestic consumption of chilled and frozen seafood products in Thailand

Source: *OIE, forecast by Krungsri Research*

As forecasted in Krungsri's research, Thailand's domestic consumption of processed seafood is predicted to remain steady or slightly grow by up to 0.5% every year. Rising levels of urbanization will enhance sales by encouraging consumers to prefer food that is both healthful and convenient to prepare. Several large firms have marketed varieties of ready-to-eat, ready-to-cook, and frozen seafood products under their own brand names through their own distribution channels or those of others.

Thai cold storage companies are currently meeting the needs of the market, one of the leading companies in B2B logistics is JWD Group, they own Pacific cold storage with leading cold storage facilities - the largest storage capacity up to 100,000 tons covering 3 key strategic locations; the

first free zone cold storage & public ASRS warehouse. It meets all the certifications to ISO 9001:2015, ISO 14001:2015, GMP, MSC, ASC, EST, Halal, FSSC 22000, ISO 22000, GMP & HACCP standards.

4. Analysis of refrigerated warehouse of Seafood in Vietnam

4.1. Current situation of Vietnam's refrigerated warehouse of cold supply chain for seafood

The cold storage market in Vietnam is still in its early stages with a fairly dynamic development. With strong demand from the food export, seafood, and frozen product industries, the supply of cold storage services is facing significant pressure.

According to statistics from the Ministry of Agriculture and Rural Development, our country annually experiences agricultural post-harvest losses in Vietnam ranging from 40% to 45%. These losses primarily occur during the production and transportation stages. The level of food loss is quite high, resulting in a significant amount of food, estimated at nearly 50%, never reaching consumers (Thanh Tam, 2018). The seafood industry is a leading export sector, reaching nearly 11 million tons in 2022 with an impressive growth rate of 24%. However, it has a post-cultivation and harvesting loss rate ranging from 20% to 30% of the total production, which equates to more than 2.2 million tons (VNS, 2023).

4.1.1. General indications (Location, capacity, suppliers)

In May 2021, Vietnam had only 48 cold storage facilities with a total capacity of approximately 700,000 pallets. Only 8.2% of domestic food manufacturers utilized refrigeration conveyor systems, while 66.7% of export-oriented enterprises did so in 2020 (Industrial Savills Vietnam, 2022).

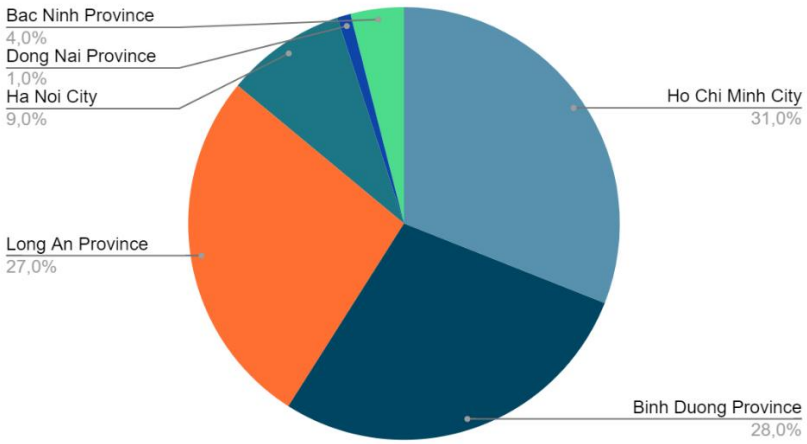

Figure 4. The Distribution of Cold Storage market in Vietnam in 2022

Source: *Research & Consulting Department, Savills*

The cold storage industry in Vietnam is characterized by its localized and fragmented nature. In 2022, there were more than 40 separate projects contributing a combined cold chain warehouse space of 460,000 square meters. (Savills Research, 2023). These facilities tend to be relatively

small and are primarily situated in major urban areas. Southern Vietnam, in particular, has a more developed cold storage sector, mainly due to the higher demand for food, seafood, and retail processing in this region. The majority of the existing cold storage facilities are concentrated in and around Ho Chi Minh City, including provinces like Binh Duong, Long An, and Dong Nai, which collectively make up 87% of the total supply. However, there has been an increasing supply of cold storage facilities in Ha Noi and the neighboring Bac Ninh province in recent years.

These cold storage providers are classified into four main groups: Foreign suppliers, domestic suppliers, logistics providers, and the others:

Table 3. The classifications of commercial cold storage providers in Vietnam.

	Infrastructure and warehouse management	**Efficiency**
Foreign suppliers	High-quality infrastructure and a professional management team. Use IT systems to manage their process.	High efficiency High price
Domestic suppliers	Small - scale companies. Basic facilities.	Low - medium efficiency Low price
Logistics providers	Few large enterprises. Use GPS positioning technology.	
Others	Small, independent cold storage.	

Source: Vietnam Association for Logistics Manpower Development

In terms of developers, domestic companies provide the most new supply. At the end of 2022, An Viet, Phan Duy, Hung Vuong, ABA Cool Trans are the largest local providers in terms of capacity, while foreign companies like Emergent Cold, PFS, and LOTTE Logistics lead in quality and services. These foreign companies offer various services, including multiple temperature zones, barcode systems, inventory management, and value-added services like product classification and labeling, ... They are often considered "Tier 1" players. (FiinGroup, 2019).

The rise of fresh food demand puts a lot of pressure on cold storage facilities in Viet Nam due to limited supply. While some large corporations are investing in their storage systems, most small and medium-sized companies still depend on the overcrowded rental market. According to FiinGroup's Vietnam Cold Chain Market Report 2019, total designed capacity of rented cold storages in Vietnam reached 600,234 pallets in 2018. The Northern market saw a significant

increase in capacity from 26,750 pallets in 2015 to 71,750 pallets in 2018, resulting in temporary oversupply and low utilization rates, especially for new facilities.

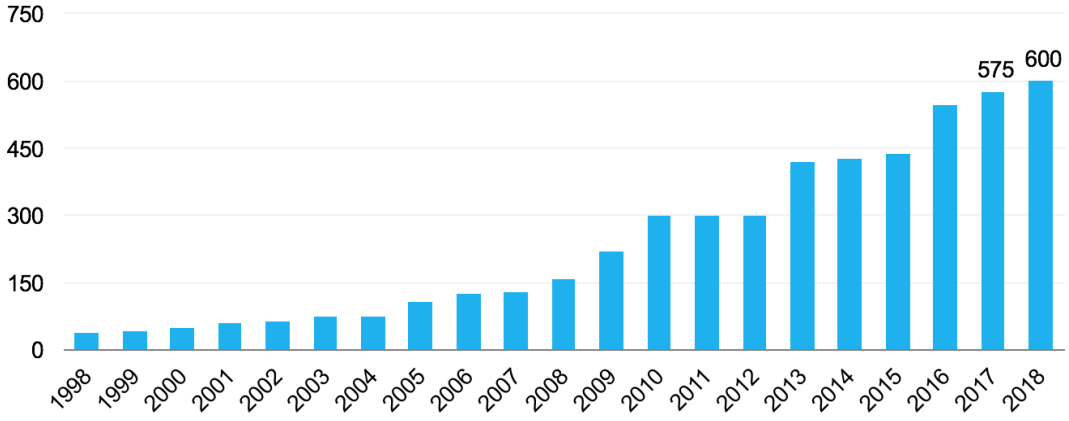

Figure 5. The designed capacity of rented cold storage in Vietnam, thousand pallets in 2018

Source: *FinGroup*

According to a report by Savills, the cold storage market in Vietnam is still considered to be developing, with a relatively small scale comprising just over 40 projects, providing a total cold storage area of approximately 460,000 square meters as of 2022. Notably, cold storage facilities for seafood and general food products by Vietnamese businesses have successfully met both domestic and international quality standards. These standards encompass various aspects, including the use of PU (Polyurethane) material for insulation, the construction of insulation panels for ceilings, floors, and walls with a thickness exceeding 10cm, ensuring a secure interconnection of these panels, and the implementation of an automatic temperature control system to maintain a consistent cold storage temperature of approximately -20°C ± 2°C. This signifies a positive step towards ensuring the quality and efficiency of cold storage facilities in the country.

4.1.2. Technology (for preserving seafood and managing warehouse)

The CAS (Cells Alive System)

CAS technology, introduced in Vietnam in 2013, uses rapid freezing with a magnetic field to preserve agricultural and seafood products. It freezes water molecules without affecting cell structures, extending product freshness, preventing water leakage, and preserving nutrition. CAS can maintain product freshness up to 99.7% (Viện Nghiên cứu Hải sản, 2020).

The MAP (Modified Atmosphere Packaging)

Modified Atmosphere Packaging (MAP) technology helps prevent the permeation of oxygen and water vapor into the packaging, with the ability to withstand high temperatures (125°C) under sterilization conditions and extreme cold temperatures (-40°C). This technology can extend the product's shelf life by 1.5 to 3 times compared to traditional packaging methods, though there is a risk of moisture condensation, and it is most effective when combined with cold storage (Dương Thu Hiền, 2020).

Chemical preservatives

The use of chemical preservatives such as inorganic salt NaCl, hypochlorite, $NaNO_2$, $NaNO_3$, various types of acids including acetic acid, lactic acid, and other substances has been considered. However, the use of these chemicals often leaves residues in the product, posing health risks to humans. Therefore, this method is typically less favored, and preference is given to natural preservation methods such as freezing and vacuum packaging to ensure food safety and environmental protection (Que Phan Thi Thanh, 2005).

The adoption rate of Warehouse Management Systems (WMS) in Vietnam is at 41.4% (Ho Chi Minh City Department of Industry and Trade, 2022). Multinational companies operating in the Vietnamese market commonly employ this system, sharing it with their parent company. Among domestic companies, only large distribution-focused enterprises such as Tan Cang Corporation, Gemadept, Vinafco, U&I, TBS, Transimex, Sotrans, etc., are developing warehouse management applications to synchronize data across delivery, inventory management, and financial accounting departments. However, for small and medium-sized enterprises, the initial investment cost remains a significant barrier. They tend to use rudimentary, decentralized software that lacks automation. This approach leads to inadequate food preservation, severely impacting product quality, resulting in losses in both quantity and value of goods and hindering export potential

4.2. Assessment of refrigerated warehouse of seafood in Vietnam

From the current situation of Vietnam's refrigerated warehouse of cold supply chain for seafood, we can see that although Vietnam's cold storage system is still in its early stages, it has made some strides. In fact, the cold storage situation in Vietnam has recently been developing rapidly and has undergone remarkable changes in many aspects. Besides the achievements, there are still long-term issues in the industry that firms and industry agencies have to handle.

4.2.1. Achievements

Large enterprises in the industry have begun building modern cold storage development systems, investing in building advanced cold storage systems to protect seafood products, meeting market demand. Hau Giang Cold Storage Logistic Co., Ltd. has launched the first cold storage company in the cold storage center investment project for external lease. Project scale includes 6 cold storages and one cool storage, with a total of 88,134 pallets, equivalent to 88,134 tons (Thu Duyen, 2022). It has also started construction of a private cold storage system, the project uses new, modern EU technology, applies digital management, and has project investment costs estimated at nearly 500 billion VND with construction investment period from 2022 - 2027 and construction progress from 1-2 warehouses/year (Thu Duyen, 2022).

Foreign businesses, as well as domestic businesses, have invested in improving seafood cold storage in Vietnam to ensure products always have the best quality by using advanced technology to maintain stable temperature and humidity control. For example, the International Finance Corporation (IFC) has invested in ITL Corp to build cold storage and warehouses in the Ho Chi

Minh City area, Alibaba's logistics company has also just built a smart logistics center. The largest smart building in Vietnam, covering 90,000 square meters and integrating cold storages to distribute domestic and export goods (Nhu Yen, 2022).

According to Mr. Le Minh Phung - Sales Director of AJ Total Vietnam Cold Storage Group, improved infrastructure in the refrigerated warehouses has helped seafood businesses build their own warehouses that meet international standards, improving the quality of storing seafood products, making Vietnam the third largest seafood exporter in the world, with seafood export turnover in 2019 of about 7.1 billion USD, and by 2022, seafood exports are expected to reach 10 billion USD.

4.2.2. Limitations

With the current amount of commercial cold storage, the demand for preserving agricultural and seafood goods to meet the needs of fresh preservation and export regime has not been solved. The Ministry of Agriculture and Rural Development stated that, particularly in the context of challenges in exporting commodities, a shortage of cold storage places enterprises under a lot of pressure when storage costs rise, items stagnate, and there is no place to preserve them, causing businesses to have suffered huge losses as a result of this (Le Hoa, 2021). The seafood export sector, according to Ms. Trang Bui, Vietnam Market Director - Global Real Estate Consulting Group (JLL), occupies the most cold storage space, however, during the peak period of the COVID-19 pandemic, up to 30% - 50% of seafood export orders were canceled or postponed, just over 40 projects, providing a total area of about 460.00 m2 of cold storage area recorded until 2022, resulting in a very high inventory requirement (Le Hoa, 2021). Even if cold storage facilities are functioning at full capacity, they are insufficient to meet demand.

The main problem is that the cost of generating cold storage remains high, so firms can only invest a limited amount in large provinces and cities in Vietnam, particularly in the Southern region. In 2023’s report of Vietnam’s cold storage, Mrs. Pham Thi Lan Huong indicated that, according to experts, the development of cold storage warehouses has 2 to 3 times the investment costs of conventional warehouses due to technological requirements, and the construction process can take up to six months. Furthermore, the lease duration typically ranges from 15 to 20 years to recover capital, and because long-term credit insurance for these assets have not been granted. With a supply capacity of only about 239,950 pallets, accounting for about 48% of Vietnam's total cold storage capacity, cold storage systems are mostly popular in Long An, with a few in Can Tho and Hau Giang, many towns, including Ca Mau, Bac Lieu, Soc Trang, and Kien Giang are considered important seafood production locations but lack serious cold storage (An Hoa, 2022). Although production costs are high, Vietnam lacks attractive incentive regulations to encourage company investment in cold storages (Nhu Yen, 2022).

And because the cost of cold storage production is high, with complicated processes and loan procedures, small-scale seafood enterprises in Vietnam can only apply low technology to the management process, still using simple software and not automating cold storage systems, resulting in the inability to preserve post-harvest products and lowering product quality when

exported. Only a few small enterprises have conventional cold storage, while the remainder are fragmented, lack consistency, and do not meet high user unit criteria such as temperature, location, and food hygiene,.. (Thu Duyen, 2022).

The lack of quality human resources in managing seafood cold storage in the cold supply chain is also a huge limitation in this industry for Vietnam. VIFFAS (Vietnam Freight Forwarding Association) estimates that the labor supply for the logistics industry only satisfies roughly 40% of demand, while in reality, most logistics service organizations in Vietnam today all confirm a shortage of highly competent human resources: most of the professional staff graduated universities but majored in fields other than logistics, some are young and have not had the opportunity to participate in policy making or direct labor force. The majority of those performing tasks such as loading, unloading, driving, and counting warehouse products have poor education levels and have not been taught in professional working styles, among other things. As a result, up to 85.7% of Vietnamese enterprises must self-train and cultivate logistics human resources through practical work at a high cost (VLA, 2019).

5. Recommendations for the refrigerated warehouse of Vietnamese seafood

5.1. Vietnam's orientation about the development of cold supply chain

Vietnam's potential for developing its cold chain logistics has been ranked 17th globally. Currently, Vietnam is focusing on improving the cold supply chain through two main areas: refrigerated warehouse and cold transportation. Accordingly, cold transportation by waterway is also a new direction to reduce cost pressures and address congestion issues during peak seasons. As the market potential continues to grow, it also requires ensuring an adequate supply of refrigerated containers and the demand for packaging materials that are lightweight, flexible, and capable of maintaining temperature over extended periods. Additionally, transportation vehicles need to be intelligent and flexible in assembling refrigerated goods, providing temperature tracking capabilities, and optimizing routes.

However, the refrigerated warehouse in Vietnam is a specialized segment of the logistics industry, but it is currently experiencing the most rapid development and investment in refrigerated warehouse centers remains an area with significant potential. According to Mr. Truong Dinh Hoe, the General Secretary of the Vietnam Association of Seafood Exporters and Producers (VASEP), the refrigerated warehouse system is a crucial link in both the production and export chains of Vietnam's seafood industry. With a projected annual growth rate of 12%, the refrigerated warehouse real estate segment in Vietnam is expected to reach a value of 295 million USD by the year 2025, as reported by Savills Vietnam.

5.1.1. Seizing opportunities

According to the Vietnam Association of Seafood Exporters and Producers (VASEP), the actual cold storage capacity in Vietnam still lags behind the needs of the industry. Meanwhile, cold storage is not only a necessary condition for businesses to purchase all the raw materials of shrimp

and fish that farmers produce but also a critical link to help businesses generate a large source of goods, meeting export contracts when market demand increases again.

Recognizing the opportunities and the need to proactively tap into the market's development potential, Vietnamese businesses engaged in cold chain logistics services have heightened their efforts. They are expanding their storage capacities and integrating automation into operations at cold distribution centers (DCs) to reduce reliance on human labor and mitigate the impact of outbreaks of diseases. Accordingly, many companies like ABA Cooltrans, a leading player in the cold supply chain with a 12% market share in refrigerated trucks and ranking in the top 3 for cold storage, and Hung Vuong Corporation (HVG) have built and put into operation distribution centers (DCs) to meet the increasing demand for food distribution in Ho Chi Minh City (Xuân Thảo, 2021).

5.1.2. Expanding the cold storage "real estate"

In Vietnam, the strong growth in demand for fresh food products, coupled with the boom in e-commerce, is the primary driver of the refrigerated warehouse market.

According to Savills' report, the revenue in the fresh food sector in Vietnam increased by 6.3% during the period from 2020 to 2022 (from USD 40.4 billion in 2020 to USD 45.7 billion in 2022). The e-commerce market in Vietnam has also witnessed significant growth, reaching a rate of 21.5% during the period from 2017 to 2022, driving the expansion of all supporting services, including refrigerated warehouse services. As per Savills' report, the refrigerated warehouse market in Vietnam is still considered to be in its early stages of development, with a relatively small scale comprising just over 40 projects. The majority of refrigerated warehouse supply is concentrated in Ho Chi Minh City and neighboring provinces such as Binh Duong, Long An, and Dong Nai, accounting for up to 87% of the total supply in the country.

Recognizing the significant potential of the refrigerated warehouse market, major corporations, large enterprises, and foreign investment funds are actively pouring capital into building refrigerated warehouse facilities and warehouses to serve export activities in Vietnam. Companies like refrigerated warehouse Logistic Hau Giang Co., Ltd. have commenced the construction of the first refrigerated warehouse facility in an external leasing center project. ABA Cooltrans, apart from investing in large cold distribution centers in major cities, also operates a fleet of refrigerated trucks with nearly 300 vehicles. Additionally, there are many other well-known names in the industry, including An Viet, Phan Duy, Hung Vuong, and many international investors like Lineage Logistics, SK Logistics, and Lotte Logistics, who are actively investing in their storage systems in the Vietnamese market(P.V). Therefore, we can notice that some large-scale corporations are investing in their own storage systems, However, medium and small-sized companies are heavily reliant on the crowded rental market.

5.2. Recommendations about the refrigerated warehouse for Vietnamese seafood enterprises

5.2.1. Close connection between government and enterprises & Wise incentives policies

The valuable lesson from Thailand's successful refrigerated warehouse development is the strong collaboration between businesses and the government. The Thai government has established an entire department within the Ministry of Commerce to oversee refrigerated warehouse-related issues, with the aim of quickly identifying and addressing the needs and concerns of businesses for timely support . As highlighted in the previous analyses, the current construction costs for refrigerated warehouse facilities in Vietnam are significantly high due to stringent technical regulations and lengthy construction procedures, resulting in costs that are two to three times higher than those in 2015. Consequently, businesses often require up to 15 years to recover their investments. It is, therefore, understandable why only a limited number of Vietnamese enterprises invest heavily in refrigerated warehouse, and even when they do, it tends to be on a smaller scale.

Drawing valuable lessons from Thailand's approach, it is advisable for the Vietnamese government to establish a dedicated department or a specialized team of 3 to 4 experts within the Ministry of Agriculture and Rural Development to closely monitor, manage, and collaboratively support businesses in refrigerated warehouse matters. Such a department could offer guidance on technical regulations and legal compliance, streamline the business permit process for construction, reducing it from 6 months to 3 months or even as short as 1 month. Furthermore, this department would collaborate with businesses to organize specialized seminars bringing together refrigerated warehouse experts and business owners. Additionally, it could facilitate exchanges between seafood producers and relevant enterprises and government agencies to ensure timely discussions and effective problem-solving. This would allow each party to share their concerns and propose solutions effective.

5.2.2. Government Incentive Policies

The Thai government has created flexible and favorable mechanisms to provide the best conditions for businesses to cooperate and develop refrigerated warehouses. However, in Vietnam, the implementation of similar support policies is still in its early stages, and the government has not shown full determination to promote the development of refrigerated warehouse systems. Businesses continue to build and manage individual and spontaneous refrigerated warehouse facilities, often to serve specific markets, leading to the relative fragmentation of Vietnam's refrigerated warehouse market.

Therefore, the relevant authorities should propose to the Government the establishment of mechanisms and policies to provide tax incentives and favorable loan interest rates for businesses investing in cold storage systems. In the short term, the Ministry of Finance should consider tax exemptions, waivers for berth rental fees, electricity costs, and cold storage services for seafood processing businesses, given the current challenges they face with rising raw material prices and reduced global demand. These tax incentives in the short term will significantly help businesses save operational costs, enabling them to allocate additional funds to invest in cold storage infrastructure. In the long term, Vietnam's diverse aquatic resources and regions necessitate a strategic planning approach for cold storage facilities, tailored to each production region and the characteristics of specific seafood types such as shrimp, fish, and crabs. This approach would

prevent spontaneous development and ensure a more efficient and region-specific utilization of cold storage resources.

5.2.3. Accelerate cold storage investments in the North

One important recommendation is to accelerate investments in refrigerated warehouse facilities in Northern Vietnam. In the northern provinces of Vietnam, aquaculture is gradually evolving into a prominent commodity production sector, expanding extensively with a focus on investing in high-value seafood varieties capable of export and yielding significant returns. For instance, in Hanoi, the estimated area allocated to aquaculture spans approximately 24,000 hectares, with a total seafood production of 123,108 metric tons recorded in 2022. In the same year, Bac Ninh province achieved a seafood production of over 40,500 metric tons. Notably, Quang Ninh province currently leads in terms of saline aquaculture production in the northern region, with a total cultivated area reaching 32,000 hectares, underscoring its significance in the aquaculture industry's regional landscape. Due to the substantial growth in seafood harvesting and trading, the number of pallets in cold storage facilities in northern Vietnam has increased rapidly, with the design capacity soaring from 26,750 shelves in 2015 to 71,750 shelves in 2018. This expansion reflects the region's efforts to meet the escalating demand for cold storage services and accommodate the burgeoning seafood industry. In recent years, Hanoi, Bac Ninh, and Hung Yen have witnessed a significant increase in their seafood supply, but they still face limitations in comparison to the southern market. Many small and medium-sized businesses in these regions continue to rely on renting cold storage facilities. Unfortunately, the rental costs for cold storage have also risen sharply, escalating from $52 to $87 within just one year. This surge in rental expenses has added a substantial financial burden to these businesses, making it a challenging aspect of their operations.

Therefore, the necessary measure to address these challenges is for businesses to consider and promptly invest in the construction of cold storage facilities in the northern provinces, especially in regions that have been strategically planned for seafood production like Hai Phong, Quang Ninh and logistics services like Hai Duong and Bac Ninh. This approach would help alleviate the two main issues at hand: the rising costs associated with cold storage rental and the insufficient supply of cold storage facilities to meet the growing demand.

5.2.4. Promote Technological Adoption

Finally, the lesson learned from Thailand's comprehensive application of technology in its refrigerated warehouse facilities is valuable for the development of the refrigerated warehouse system in Vietnam. In reality, many small and medium-sized enterprises in Vietnam that use refrigerated warehouse support software still have simple and unsynchronized systems. Therefore, businesses should focus on investing in technology infrastructure to significantly improve product quality, reduce losses, and enhance the competitiveness of Vietnamese seafood products. .To achieve this, once again, the importance of joint ventures or collaborations between enterprises needs to be emphasized because small enterprises can learn from the technology of larger enterprises.

6. Conclusion

The cold chain is increasingly playing a crucial role in the global supply chain. It is a key element in the storage and transportation not only of seafood, meat, fruits and vegetables but also pharmaceuticals on a global scale. Therefore, Vietnam is not exempt from this supply chain.

Through an analysis of Thailand's seafood refrigerated warehouses, some of Thailand's successes in seafood preservation have been highlighted as lessons for Vietnam. Additionally, the group has assessed the strengths and weaknesses of Vietnam's cold storage facilities for seafood storage. Although many businesses have joined the cold supply chain and invested in seafood cold storage, the number and capacity of cold storage facilities remain limited, failing to meet current demands. Furthermore, small cold storage facilities in Vietnam have not widely adopted advanced technologies, and some still rely on outdated management practices.

Therefore, to develop Vietnam's seafood cold storage, there is a need for government support packages for businesses. Additionally, there is a particular focus on developing refrigerated warehouses in the northern region to maximize the utilization of seafood resources in that area. Lastly, the application of modern technologies will contribute to increased efficiency in the operation and management of Vietnam's seafood cold storage.

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