THE IMPORTANCE OF TECHNOLOGY AND COLD CHAIN LOGISTICS IN VIETNAM'S PRESERVATION OF HARVESTED SEAFOOD

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ABTRACT

Vietnam has been experiencing significant economic growth in recent years, making it an attractive destination for foreign investors. With globalization and the expansion of trade relationships, logistics management has become crucial for domestic and multinational companies operating in Vietnam. However, logistics operations in Vietnam are exposed to various risks, such as natural disasters, infrastructure issues, regulatory uncertainty, and human factors. Therefore, it is essential to manage logistics risk effectively to ensure the supply chain's resilience and the business's sustainability. This paper aims to provide a critical review of the risk management literature in logistics by analyzing the key concepts of supply chain risk, the principles of logistic risk management, types of logistics risks, and some ideas on solutions in risk management in the supply chain.

***Keywords**: Supply chain, risk management, Vietnam*

I. INTRODUCTION

Vietnam is a coastal country on the west bank of the East Sea, with geostrategic and geoeconomics that not all countries have. With a coastline that stretches over 3,260 kilometers from north to south, from Mong Cai in the north to Ha Tien in the southwest (not to mention the coast of islands), Vietnam ranks 27th out of 157 coastal countries. With over 3,000 large and small islands, including two archipelagos, Hoang Sa and Truong Sa, Vietnam is regarded as one of the countries with great potential and advantages in marine and island resources. [1]

According to the data presented above, Vietnam has enormous potential for developing fisheries, fishing, and aquaculture. In particular, total seafood output reached 8.4 million tons, employing approximately 800,000 workers directly at sea and nearly 4 million logistics service workers. The fishing community‘s material and spiritual life is improved, which contributes significantly to alleviating poverty, nutrition security, and economic development. [2]

Vietnam‘s fisheries have a long history of formation and development as one of the professions contributing to sustainable agriculture. Currently, Vietnam‘s fisheries must meet the criteria for combating illegal, undeclared, and unregulated fishing, which is assisting in some reform in terms of equipment, technology, and compliance with international customer regulations. Furthermore, due to the lack of appropriate preservation technology and cold chain logistics for aquatic products that have not been developed, seafood quality is low and post-harvest loss is high. That is also why the author chose to conduct research in Vietnam on cold chain logistics and preservation technology. The following sections comprise this article:

- Research Methodologies
- The current state of technology application and cold chain logistics development in post-harvest seafood preservation,
- Post-harvest seafood preservation technology and cold chain logistics
- Case studies - Solutions and advice

II. METHODS

The study's specific objectives are as follows:

- OB1: Determine the status of post-harvest seafood preservation and loss in Vietnam;

- OB2: Gaining an understanding of the current state of technology application and cold chain logistics in post-harvest seafood preservation in Vietnam;
- OB3: Advanced post-harvest seafood preservation technologies from around the world and in Vietnam;
- OB4: Global and Vietnamese advanced technologies in cold chain logistics;
- OB5: Solutions to improve cold chain logistics and increase the use of technology in post-harvest seafood preservation.

To achieve the goals of this study, the author employs qualitative research methods such as secondary data research, survey research, interviews, and expert interviews.

Business scholars are constantly constrained by time and money limitations. Therefore, it is prudent for them to inquire if the necessary data to examine the study's queries already exists. If so, the analysis can be conducted rapidly, effectively, and at minimal expense. Consequently, research projects should commence with secondary data, which have been collected and recorded by someone else for purposes other than the current project. Typically, secondary data are already compiled. They need no access to subjects or respondents.

A survey is defined as a method for acquiring primary data from a representative sample of people through conversation. Surveys provide a moment-in-time snapshot. The more formal term, sample survey, highlights that the goal of contacting responders is to collect a subset or sample of the target population.

An in-depth interview is a one-on-one conversation between a professional researcher and a research participant. However, depth interviews serve a distinct purpose than psychological or clinical interviews. The researcher poses numerous questions and probes each response for further clarification.

The table below describes in detail how to use each research method for each specific goal.

Table 1. Research methods used in the article.

Objective	Research Methods
OB1	A survey of approximately 30 seafood enterprises in Vietnam was conducted, as well as in-depth interviews with 5 seafood enterprises.
OB2:	Secondary data and in-depth interviews with five seafood businesses were used.
OB3:	Using secondary data, in-depth interviews with 5 seafood enterprises, and interviews with 5 cold chain and seafood experts
OB4:	Using secondary data, in-depth interviews with 5 seafood enterprises, and interviews with 5 cold chain and seafood experts
OB5:	In-depth interviews with 5 seafood businesses, as well as 5 cold chain and seafood experts

III. CURRENT SITUATION

3.1. Achievements and challenges

Numerous studies on the utilization of technology in processing aquatic byproducts in Vietnam, such as the production of biogas, animal feed, and microbe fertilizers, have been conducted by the Institute of Agricultural and Post-harvest Technology. However, the outcomes of these applications are mostly on a small scale, with only a few large corporations investing in and developing industrial-scale applications.

In terms of dried seafood preservation technology, the institute has established a specialized laboratory to investigate basic biochemical changes, chemical reactions, and the development of microorganisms and fungi in dried products. Equipment in Vietnam can fully master equivalent techniques in the region and around the world for refrigeration and frozen storage technology. Appropriate preservation methods have been devised.

When it comes to refrigeration and frozen processing technology, Vietnam's pre- processing and raw material processing equipment for seafood can design and manufacture technology with a mechanization and automation level 40% higher than the global average. Except for specialized refrigeration components that are commercialized worldwide, Vietnam can manufacture and install rapid freezing technology equipment (refrigeration compressors and accessories). The domestication rate for forced air freezing chambers is approximately 80%, while the IQF freezing system is approximately 50%.

So far, the Institute of Agricultural and Post-harvest Technology has successfully researched and applied super-fast liquid freezing technology at the Ba Hai Seafood Processing Company in Phu Yen province for exported seafood (ocean tuna, squid, whiteleg shrimp, and oysters). Super-fast liquid freezing technology outperforms IQF freezing technology in terms of freezing time, saving more than 50% on electricity costs, and improving product quality.

The role of small and medium-sized enterprises (SMEs) in the Vietnamese economy, on the other hand, is still being assessed. According to the Institute of Agriculture Policy and Strategy, the majority of seafood enterprises are SMEs, and most technologies have gone through three or four generations. SMEs account for a high proportion of total enterprises in developed countries, ranging from 90% to 98%, and contribute to economic growth, accounting for 65% of GDP in the EU and more than 50% in the US.

3.2. Reduce fishing and increase exports

According to the most recent report from the Directorate of Fisheries (Ministry of Agriculture and Rural Development), fishing output in 2021 will be 3,886 million tons, up 0.9% from the previous year. At the same time, the value of seafood exports has reached 8.899 billion USD, with seafood alone accounting for 3.4 billion USD, a 6.7% increase over 2020. [3]

From the start of 2022 to the present, the total output of exploited seafood has reached

566.7 thousand tons, an increase of 0.1% over the same period in 2021. However, all production targets were met, with the export turnover of fishing products increasing by 0.9% and the average fishing productivity per vessel increasing by 3.5%. [4] Many offshore fishing vessels have recently been built, with large-capacity machinery and advanced and modern fishing equipment.

According to data, there were 86 grassroots fisheries unions in 16/28 coastal provinces and cities by the end of February 2022, with nearly 17.7 thousand members and over 6.2 thousand ships with a length of 15m or more. Over 4.2 production teams are at sea, with nearly 29.6 thousand fishing vessels participating. Furthermore, the total value of seafood exports in the first two months of 2022 reached US$1,508 billion, a 51.1% increase over the same period the previous year. With a total export turnover of 573 million USD, seafood exports accounted for 38% of the total export turnover of the entire seafood industry. Tuna, squid, octopus, and crabs are among the seafood species with high export turnover. [5]

Chain models in the maritime industry are also rapidly evolving, with companies placing orders for product preservation standards to ensure quality and traceability in order to receive product offtake.

3.3. Stages of preservation and processing

The Vietnamese seafood industry expects to harvest around 8.7 million tons of seafood in 2022, which is 99.9% of the previous year's target. This amount will be made up of 3.78 million tons from fishing (97.1% of the previous year) and 4.95 million tons from aquaculture (102% of the previous year). Seafood exports are expected to total $8.7 billion, with seafood accounting for 37-39% of total exports. Seafood preservation and processing are critical to achieving the goal of reducing fishing activities while increasing the value of seafood exports. [4]

Currently, Vietnam has 354 ice-making factories, 640 cold storage warehouses with a total capacity of approximately 78,700 tons, and 14 warehouses for rent with a capacity of 46,000 tons. There are also nine seafood classification facilities capable of handling 240 tons of seafood per day, as well as over 1,100 seafood buying and trading facilities. [4] However, the seafood processing industry is facing challenges such as overcapacity and a shortage of raw materials.

Vietnam's seafood processing technology lags behind that of other countries and industries, such as vegetable and wood processing. To address these challenges, the Ministry of Agriculture and Rural Development is developing a seafood processing plan with the goal of having at least 60% of seafood processing facilities meeting advanced production technology standards by 2030, on a large and modern scale comparable to the region and the world. The value-added growth rate is expected to average more than 10% per year, with deep-processed seafood products accounting for 45-50% of total value.

3.4. The current state of technology application in fishing

The General Department of Fisheries reported in 2015 that on average, about 30% of the total production of aquatic products in Vietnam was lost or damaged during and after harvesting, meaning that nearly one million tons of aquatic products were lost or damaged out of the total production of three million tons of aquatic products harvested in 2015. [6] Up until now, the loss of harvested aquatic products remains significant and even higher than before due to limitations in technology such as small machine capacity, the use of outdated equipment, low productivity and post-harvest preservation technology. The number of fishing boats and fishing vessels is high, but most of them have small capacities, and the post-harvest preservation methods are still outdated, such as using traditional methods of preserving with crushed ice or salted fish, leading to inadequate refrigeration for maintaining and preserving the products, resulting in high losses after harvesting. Although some advanced fishing technologies have been applied in developed countries, such as fishery forecasting technology, shipbuilding technology, ship hull materials, and post-harvest preservation technology, as well as advances in communication technology, in reality, the application of these technologies is still limited. First of all, information on technological advances is slow to be disseminated and there are few practical models for fishermen to follow. Moreover, these are new models that require investment in capital and time, so fishermen are cautious. In addition, businesses have not been able to access fishermen.

The goal of applying scientific and technological advances in fisheries exploitation is to increase added value, reduce labor, improve production efficiency, and selective exploitation to promote sustainable development, avoid overemphasis on production volume, and address the problem of loss during harvesting and preservation of post-harvest products. Therefore, to promote the application of science and technology in fisheries exploitation in the near future, the General Department of Fisheries has compiled technical progress documents on fisheries exploitation, which will be disseminated through various media such as television, newspapers, and websites to provide fishermen with quick and easy access to information.

It is important to promptly develop and submit a plan for the application of science and technology in fisheries exploitation to the competent authorities. This plan must include a roadmap and specific measures to facilitate the widespread application of advanced technologies in fisheries exploitation, ensuring that the benefits of these technologies are realized, contributing to the sustainable development of the fishery industry in Vietnam.

3.5. Challenges in the seafood industry

In 2020, Vietnam achieved a production of 8.45 million tons in fisheries, of which 3.85 million tons were from fishing and the rest from aquaculture. In addition, the value of seafood exports reached 8.5 billion USD. However, the seafood industry faced many difficulties that year, including the impact of COVID-19, flooding, storms, saltwater intrusion, climate change, and other weather events that directly affected production. [7]

Moving into 2021, the industry is facing new challenges. One major issue is that the European Union (EU) has issued a "yellow card" against Vietnam's fishing industry, which has been in effect since October 23, 2017. Although 14 countries have been able to lift their "yellow cards," Vietnam is still working to do so, along with six other countries that have received "red cards." This has created difficulties for Vietnam's seafood exports, as the "yellow card" affects credibility, administrative procedures, and seafood control measures in the EU and other markets. [8]

Another challenge is related to overfishing, which has been a problem for many years. With a fishing fleet of over 110,000 vessels, Vietnam had to restructure and reduce this number to 96,000 vessels, and now to 94,572 vessels. However, this number is still too high given Vietnam's fishery resources. With the implementation of the 2017 Fisheries Law, Vietnam will continue to review and limit fishing capacity, especially in sensitive areas.

The infrastructure of the seafood industry is also a significant challenge. Although seafood exports reached nearly 9 billion USD in 2019, with a production of nearly 3.9 million tons, the industry has not received sufficient investment. This has led to serious degradation of fishing ports, berths, and other facilities. This situation makes it difficult to manage the fishing fleet and prevent vessels from violating regulations. In addition, tracing the origin of seafood is another challenge, as harvested fish must be sorted at the port to reduce post-harvest losses. At present, losses after harvesting are between 15-35%, making it challenging to trace the origin of the fish.

Overall, the Vietnamese seafood industry faces various challenges, such as overfishing, poor infrastructure, and difficulties with seafood export markets. These challenges need to be addressed to ensure the industry's sustainable development.

IV. Technology And Cold Chain Logistics In Post-Harvest Seafood Preservation

Using the most advanced techniques and high technology, seafood processing facilities have transitioned from manual to automated lines to exploit, preserve, process, and package aquatic products. Automation robots, control systems, monitoring systems, conveyor belts, automatic canning, vacuuming, sterilization, and packaging are all used sequentially and controlled in the automation line. An industrial computer is in charge. The application of high technology has many economic, health, and environmental benefits, such as saving time and labor, increasing production efficiency, ensuring product quality and freshness, and minimizing negative environmental impacts.

4.1. Cells Alive System (CAS)

CAS (Cells Alive System) technology is a new refrigeration method for agricultural products and food preservation. CAS is a fast freezing technology that uses magnetic fields to act on the cells of agricultural products, aquatic products, and food, causing water molecules to freeze but not bond with each other, preserving cell structure. The product keeps for a long time without losing water or nutrients. CAS technology can keep fresh products cold for up to 99.7% of the time and for up to ten years, assisting in the reduction of post-harvest losses and deterioration in the quality of food and seafood products. In general terms.

Mr. Norio Owada, president of ABI Corporation (Japan), and his research team developed CAS. This technology has been licensed to over 20 countries and has been patented in the United States. CAS is produced by combining low temperature freezing with magnetic field fluctuations ranging from 50Hz to 5MHz. To this extent, magnetic field oscillations are capable of preventing free and bound water in living cells from freezing into large masses, but forming only microscopic particles, known as "supercooled water". Because there is no crystallization into large plaques, there is no breakage of food cell membranes and no release of intracellular enzymes, preserving the product's color, taste, and quality.

CAS (High Frequency Magnetic Field Technology) is made up of two major

components:

- Freezers: This machine works on the principle of supplying energy into the food in order to reduce its temperature to the required level. This freezer assists in maintaining a low temperature to prevent food from dripping after defrosting.

- Magnetic Field Generator, 50Hz to 5MHz: This unit generates a large and continuous magnetic field between 50Hz and 5MHz. This magnetic field will penetrate the food, causing the molecules within to vibrate and twist together, resulting in the formation of a new structure between the molecules.

This technology has numerous advantages for food, including:

- Prevents food from dripping after defrosting, preventing nutritional components such as protein from being lost.

- Good water retention, preservation of amino acids, fresh flavor, and natural color of food.

- Extends the shelf life of food by inhibiting the growth of bacteria and mold.

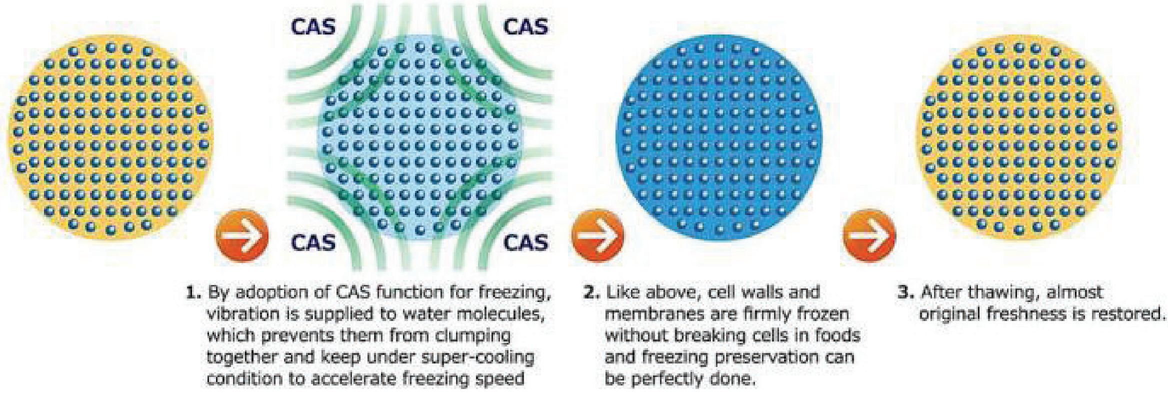

Figure 1. Food Freezing Image by Quick Freezer with CAS Function.

4.2. Slurry ice

Using slurry ice has been widely applied on fishing boats in countries with developed fishing industries since the 1980s. The effectiveness of slurry ice technology has been demonstrated and verified worldwide, including in Vietnam in recent years. Slurry ice is made from seawater, actively on the sea, at a low temperature below 0°C without solidifying into hard lumps, suitable for the production scale and conditions of the fishing industry in Vietnam. Applying slurry ice for on-board preservation reduces losses after harvesting, improves the quality of fish, and enhances the quality of offshore fishing vessels participating in the supply chain of export products.

Slurry ice, also known as liquid ice, slurry ice, or snow ice, is a homogeneous mixture of small ice particles and liquid. Slurry ice has many advantages such as high energy storage density, rapid cooling due to the very small size of ice particles, therefore, it can easily penetrate inside the object to be cooled, maintains low temperature continuously throughout the cooling process with a high heat transfer coefficient. Slurry ice is lightweight, does not crystallize into hard lumps, easy to preserve and unload, does not cause damage to aquatic products, reduces bruising or crushing of aquatic products during preservation because it is a liquid environment; slurry ice can adjust temperature, as it has a low temperature of -20°C to -40°C, so the shelf life of aquatic products can be extended to 25-30 days.

Fishing boats in Vietnam operate offshore with a trip duration of over 20 days. The harvested products are preserved by crushed ice brought from shore, therefore, the quality of fish decreases sharply after 10 days of preservation. If the fishing trip lasts over 20 days, the boats have to sell fish to other boats at a lower price. For ocean tuna fishing, there is no on-board purchasing, so all harvested products are brought to the port and sold to warehouses. Tuna fish preserved with crushed ice for over 12 days also decrease in sensory and biochemical quality.

Traditional crushed ice preservation technology is no longer suitable for offshore fishing boats with long-term sea stays as nowadays. The problem is to find a technological solution to prolong the preservation time to match the trip duration while maintaining the product quality.

Long-term freezing technology prolongs the preservation time, but the harvested products are frozen so when returning to shore, the classification, thawing and selling to the warehouses becomes difficult and not suitable for actual production, and the product quality decreases during the thawing process. In addition, the scale of fishing boats in Vietnam is small, mainly wooden boats, which limits the application of long- term freezing technology. Therefore, using slurry ice for on-board preservation is the most appropriate and effective solution for the current fishing industry in Vietnam.

4.3. PU-based material storage cellar

Fishermen are increasingly utilizing the storage tunnel made of Polyurethane (PU) material on fishing boats. The storage cellar is made of high-tightness PU material that does not allow heat to escape and prevents water and outside air from penetrating. In fact, using a Pu cellar has many advantages over traditional cold storage methods. The PU storage cellar saves 30% of the amount of ice lost, extends storage time, and improves the quality of seafood raw materials after exploitation... Usually up to 12-15 days, but the quality of preserved materials is still good after 15 days in a PU cellar.

The application of scientific and technological advances in the exploitation and preservation of aquatic products after exploitation resulted in some initial successes. However, the fishing industry remains a heavily manual industry in general; many stages of production still require direct labor, labor productivity is low, and the catches brought to shore are extremely dangerous. The amount of science and technology available is limited, and post-harvest loss is 20-30%. Transfer and application of water resources should be developed in order to improve fishing efficiency, ensure the safety of people and vehicles when operating at sea, and improve the working and living conditions of workers on board. The application of scientific and technical technology in the field of fishing needs to be a top priority because this is a vital factor for fishermen.

4.4. Nanotechnology

Nano UFB (Ultra Fine Bubble) is a modern preservation technology that helps fishermen keep fish fresher after catching than traditional methods. The technology creates ultra-fine gas bubbles with a diameter of nanometers by infusing nitrogen gas into a bubble generator and mixing it inside the device through nano-tubes to create a solution of negatively charged nitrogen gas bubbles that effectively remove organic matter with a positive charge from the water.

The nano nitrogen bubbles will remove dissolved oxygen in the water, reducing the activity and development of aerobic bacteria, thus preventing oxidation from the outside surface to the inside of the fish's body. This helps preserve the fish and prevent it from spoiling.

The nano UFB system consists of three machines: a nitrogen gas generator, a nano nitrogen bubble generator, and a nano nitrogen foam generator. 78% of the nitrogen gas in the air is extracted and separated at a rate of 99.9%. After separation, nitrogen gas is converted into molecules smaller than 100nm and then transferred through tubes to a fish storage chamber where it is neutralized with cold seawater and ice at a ratio of 1:2 to create a saline environment similar to that of the fish.

The nano nitrogen foam, created by absorption, will remove all dissolved oxygen in the water. When this happens, the dissolved oxygen content in the storage chamber is almost zero. The lack of oxygen and low temperature from -1 to -1.5C will make the anaerobic microorganisms almost inactive, which is favorable for preserving fish.

Moreover, the ultra-fine size of the nano nitrogen foam will penetrate deep into the fish meat, isolate oxygen, and prevent the oxidation of fat from the outside surface and inside the fish's body, helping the fish stay fresh longer during preservation. The system consumes low power as it runs only for about three hours before the fish is placed inside and runs for one hour every four days to maintain operation.

The Fisheries Sub-department of Binh Dinh province, in coordination with the Binh Dinh Agricultural Promotion Center, has selected qualified fishing boats to build a tuna preservation model using nano nitrogen foam technology. About 30 fishing boats are expected to be selected for trial implementation, with each boat being supported with 40% of the cost, equivalent to about 40 million VND to invest in the system and storage chambers. In the second quarter of 2022, the authorities will choose two fishing boats to implement the model, and the results will be evaluated before expanding to other fishing vessels.

Conclusion demonstrates new fi ndings in the research and how do the ideas in the paper connect to what the author(s) have described in the introduction and discussed.

V. AQUATIC PRODUCTS PROCESSING AND PRESERVATION

5.1. The procedure for processing seafood products

Frozen preservation: To ensure food safety and product freshness, seafood products are frozen from the start of processing. Ice is made from clean potable water using a flake ice maker system and is stored in different areas of the processing workshop. When semi-finished products are on the line, the temperature is kept below 10^{o}C, and when waiting for the next stage, it is kept below 4.4^{o}C.

Freezing and freezing cold storage: Use modern freezing systems to quickly reduce the core temperature of the product to below -18^{o}C. To avoid product spoilage, the product is packaged immediately after freezing and stored in a cold storage with a constant temperature of -25^{o}C to -20^{o}C. The goal is to maintain the product's quality and freshness by almost completely inhibiting all bacteria and enzymes, allowing the product to be circulated with the same quality for two years.

Using metal detectors: After freezing, products in PE packaging will be run through metal detectors with increasingly stringent detection levels. This device ensures that there are no metal fragments in any shrimp or fish.

5.2. Process of product preservation

In fact, modern fishing vessels do not use the stages of salting, soaking, and cooling seafood with cold sea water before putting it in the storage cellar. Instead, vessels place enough crushed ice on the bottom of the hold before loading trays of fishery products. This is a simple but effective method for preserving aquatic products. The ice's coldness will help to lower the temperature inside the cellar, keeping the product fresher and reducing the risk of microbial growth.

Moreover, fishing vessels now use temperature control systems to keep fishery products at the proper temperature during transport. This reduces the rate of product loss due to damage while also ensuring the quality of seafood products for consumers. Besides that, fishing vessels now use more advanced technologies for quality control of fishery products, such as moisture, acidity, turbidity, and other chemical analysis systems. All these technologies contribute to the quality of seafood products reaching consumers.

VI. CONCLUSION

Technology and cold chain logistics are essential to the preservation of harvested seafood in Vietnam. Advanced technologies such as the Cells Alive System (CAS), slurry ice, PU-based material storage cellars, and Nanotechnology assist in preserving the sensory characteristics, nutritional value, and shelf life of seafood products. Logistics involving the cold chain, including storage, transport, and dissemination, is a crucial aspect of seafood preservation. However, their implementation in Vietnam faces several obstacles, including a lack of infrastructure and awareness among marine producers. Collaboration is required to address these challenges and maximize the potential of technology and cold chain logistics. Vietnam can improve the quality, safety, and marketability of its seafood products by adopting advanced technologies, implementing efficient cold chain logistics, and addressing associated challenges, thereby benefiting the seafood industry and contributing to the overall economic growth and sustainability of the country.

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