

# Frozen Tilapia Fillets Business Process Analysis Using Integration Definition for Function Modelling

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## **Abstract**

*Aquaculture products in Indonesia have great potential in line with population growth. The demand for frozen tilapia fillets is increasing both in Indonesia and globally. Our objectives are to identify the current business process activities of a frozen tilapia fillet product, analyse problems and provide improvement strategies. In-depth interviews and observations were conducted with stakeholders. The business processes were analyzed using an Integration Definition for Function Modelling (IDEFO) to identify the activities and problems at the organizational level, the production plant level and the production department level. The results at the production plant level showed that there was a lack of strategic forecasting and inventory management in the planning activity. In the sourcing activity, the limited number of suppliers and inconsistent fish quality were the main problems. The lack of implementation of a good material handling and production system was a concern in the making activity. The problem in the delivering activity was the lack of product tracking which results in product returns due to defects. The researchers' recommendations, based on several literature reviews, are expected to improve the supply chain of frozen tilapia fillets in Yogyakarta and Central Java to increase its competitive advantage.*

**Keywords:** *Aquaculture, Frozen Tilapia Fillets, IDEFO*

## **1. INTRODUCTION**

According to Food and Agriculture Organization (FAO) 2022, global aquaculture foods consumption increased at an average annual rate of 3 percent from 1961 to 2019, a rate almost twice of annual world population growth. Research showed that aquaculture production is positively related to the consumption of aquatic food in 163 countries (Garlock et al., 2022). Indonesia's aquaculture is expected to continue growing to meet fish consumption demand (Tran et al., 2017). Tilapia had the highest production at 1.4 million tonnes in 2019, according to data on aquaculture production in Indonesia by major commodity (Central Bureau of Statistics (Indonesia), 2019). Tilapia trade and forecasts have received considerable attention in recent years, particularly in the US market, which accounts for 70% of the global tilapia market (El-Sayed, 2020). Indonesia, followed by China and Colombia, is the third largest exporter of tilapia to the US market. Indonesia's supply of frozen tilapia fillets is a leading exported product that has seen steady growth in the US market over the past 20 years. However, tilapia products from China and Indonesia have been unable to meet the demands of US consumers. Tilapia products from Indonesia were greatly preferred by American consumers, despite having a higher price compared products from China. This indicates that the tilapia industry in China is growing much faster than in Indonesia (Dai et al., 2020).

In contrast, perception of value, product packaging and consumer lifestyle have a significant impact on the purchase value of frozen food during the pandemic in Indonesia (Chianardi and Permatasari, 2020). Frozen tilapia fillets have a high demand regarding the categories of frozen food consumed during covid-19 pandemic (Janssen et al., 2021). Since the pandemic, the cold chain system in Indonesia has grown, particularly for the supply of agro-industrial products. The cold supply chain for aquaculture in Central Java is implemented to maintain quality (Guritno and Ryanjani Tanuputri, 2017). The cold chain system has several advantages for fisheries products to minimize physical, microbial, and chemical degradation of food quality (Kitinoja, 2014). An analysis of the current cold supply chain in Indonesia, focusing on the business processes of third-party logistics providers, revealed that it is still poorly implemented and inefficient (Pradita and Ongkunaruk, 2019). Integrated inventory management, databases, and traceability systems are also required in the cold supply chain of frozen products. Although the cold chain is appropriate for handling fishery products, its application faces

several challenges (Arista et al., 2022). In addition, frozen tilapia products have good development potential according to consumer demand in both local and export markets. Therefore, business process analysis of frozen tilapia fillets was conducted in this study to identify problems, then improvement strategies were provided to improve product competitiveness.

## **2. MATERIAL AND METHODS**

The qualitative method involved observation and in-depth interviews with stakeholders in the frozen tilapia fillet supply chain in Yogyakarta and Central Java, using a questionnaire as a tool to obtain data for analysis. In the downstream process, each level of the supply chain was represented by three respondents. In the upstream process, the production plant and the 3PLs were each represented by one respondent in a managerial position who was considered to have a better understanding of the business process. The exporter and customer levels were represented by two respondents each. This research is more specifically focused on data collection at the production plant by conducting in-depth interviews with the production manager of one of the frozen food manufacturers. Respondents are responsible for gathering required information about activities and problems on each tier of the frozen tilapia fillet supply chain. Then, the business process has been identified by using Integration Definition for Function Modelling (IDEF0) level 0 for all stakeholders, level 1 for the company level and level 2 for the production department. The higher level indicates activity in a more detailed business model. IDEF0 is used to model and analyze complex systems, study the functioning and interrelationships of systems, and the activities present in the company's business model. IDEF0 for the development of strategic plans is carried out in micro, small and medium enterprises (Waissi et al., 2015). The advantage of IDEF0 modelling technique is that it permits the user to specify a complete system design to as complete level of detail as desired. The main components in IDEF0 are the functional boxes that represent the activities of each process and four arrow functions including input, output, control and mechanism of each activity (Tangkham and Ongkunaruk, 2019). The left arrow entered in the box shows the input, which is the factor that drives the activity. The right arrow leaving the box shows the output that is the result of performing the activity. The arrow from the top into the activity box shows the control such as standards, regulations or activity requirements. The arrow that enters the box from the bottom shows the mechanism implying resources such as humans and equipment or machines in carrying out activities. The solid line shows current activity and the dashed line offers recommendations for improvement in tilapia fillet frozen supply chain. Furthermore, researchers provide recommendations based on several literature reviews according to the problems encountered.

## **3. RESULTS AND DISCUSSION**

### **3.1 A frozen tilapia fillet supply chain**

The supply chain of frozen tilapia fillets starts from the breeder as the first tier to the end consumer as the last tier. The breeder breeds the fish until the larvae emerge for about 20 days. Then the fry are cared for by the spreader, the third tier, for approximately 60 days. The next tier is the enlarger, which is carried out for 3-4 months until the fish reaches consumption size. Collection centers collect the consumable fish from the enlarger and resell them to production plants, retailers and end consumers. Breeders, spreaders, enlargers, and collection centers are located in Sleman, Yogyakarta and Klaten, Central Java. In addition, the tilapia for consumption will be sent by the collection center to the production plant in Semarang, Central Java, a distance of approximately 110 km with a travel time of 2-3 hours. After the fish is processed, the frozen tilapia fillet will be delivered to Tanjung Mas using refrigerated containers from third party logistics providers (3PLs). The products are exported from the Tanjung Emas port using a cold chain system. Central Java Province exported tilapia products to six countries in 2020 with a volume share of destination countries (%) to Australia by 2.6%, Germany by 3.8%, Thailand by 4.59%, Canada by 6.72%, Netherlands by 23.54% and United States by 58.75% (Suhana, 2022). The consumers of these products are business-to-business (BTB) such as retail supermarkets and horeca (hotels, restaurants, cafes) and end consumers.

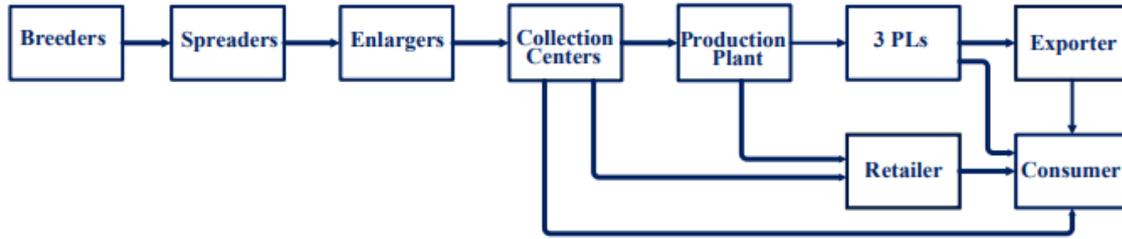


Figure 1. A frozen tilapia fillet supply chain

**3.2 Business process analysis of a frozen tilapia fillet**

**3.2.1. The business process of frozen tilapia fillets at the organizational level (IDEF0 Level 0)**

The organizational level of the stakeholders is drawn in IDEF0 Level 0, which is shown in Figure 2. For this figure, the relationship between the stakeholders in the business process can be identified and analyzed. Previously, the collection centers only used experience-based forecasting without considering seasonal and historical data. The lack of forecasting management leads to stock shortages that cannot meet consumer demand, or even overstocking due to poor handling during the harvest season. In the collection centers, there is a suggestion in the input to make strategic forecasts. Therefore, to improve accurate forecasting, an appropriate forecasting strategy is needed through quantitative and qualitative with the required mechanism is a spreadsheet (Fildes et al., 2019). The spreadsheets are required because, previously, collectors only used manual records, which were not well organized. The delivery of fresh fish by the collectors is usually by means of box trucks that have oxygen added for live fish, or ice for dead fish. However, some fish die before they are delivered, and collectors generally sell them to end consumers at low prices as their quality declines. Therefore, a freezer is needed in the collector to preserve the dead fish before shipment, so that the quality remains good and can be sold at a high price.

In the production plant, there should also be improvements in the input section to use a more accurate strategic forecast as in the collector that uses quantitative forecast to realise the data history and qualitative forecast such as forecasting weather conditions. A qualitative forecast is very important to do because the product handled is a very sensitive aquaculture product to weather changes. Production plants have a greater demand than the existing supply, but the capacity within the company is not met or has a lack of capacity. Labour is the capacity in this case because almost the entire process of producing frozen tilapia fillets is done manually. Therefore, when demand is high, it would be better for the company to increase its capacity by outsourcing labour (Francas et al., 2011).

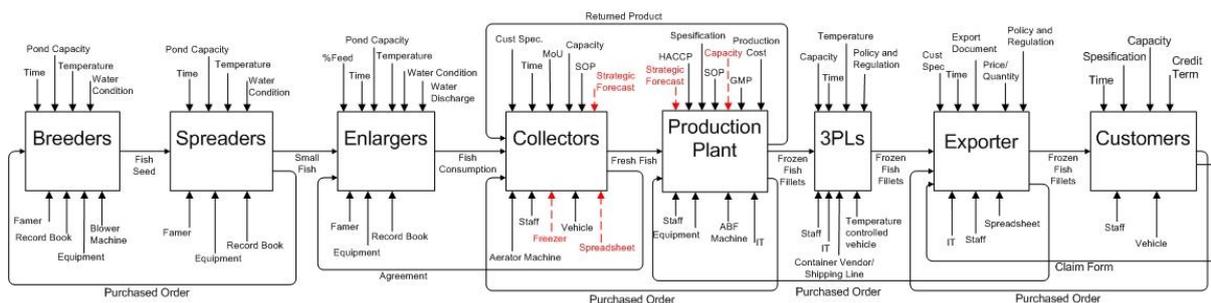


Figure 2. IDEF0 level 0 (organizational level)

**3.2.2. The business process of frozen tilapia fillets at the production plant level (IDEF0 Level 1)**

In IDEF0 level 1, all activities that occur in the production plant are categorised as plan, source, make, deliver and return. Figure 3 shows the business process of the frozen tilapia fillet production plant. The solid line represents the current situation and the dashed line represents the proposal offered in this production plant. In the planned activity, the given suggestion is strategic forecasting and inventory management. Inventory management is necessary because sometimes when there are a lot of raw materials, raw materials are stored together with finished products. Therefore, there must be

good inventory management to maintain the quality of the products (Wild, 2017). In the source activity, the company uses suppliers from Sleman, Yogyakarta and Klaten, Central Java, so the production only depends on suppliers from both areas. Therefore, the company should add suppliers from other regions in Central Java. Routine supplier evaluation should also be done because there is no evaluation for suppliers.

In the make activity, the company must add a percentage of productivity as a key performance index (KPI). Productivity is the ability of the industry to produce the finished product (Gidwani and Dangayach, 2017). The company uses the services of a third party logistics provider for the delivery of the finished product, which is delivered using a refrigerated truck that is actually equipped with a thermo-logger. However, the company does not regularly check the temperature during transport. Therefore, it needs real-time control of the input and also a KPI in the form of delivery lead time, as currently the company only uses the estimated time. Real-time monitoring is very important when transporting perishable goods. Transported goods are monitored during transport and mitigation plans are implemented when deviations from optimal transport conditions occur and there is a risk of damage to goods or deterioration in product quality. Optimizing a cold chain system that provides optimum refrigeration during transport requires complete system integration, not just specific processes (Lailossa, 2015). For the return activity, the KPI required a percentage of defects to be measured by the company. Exporters can return products if the products do not meet the pre-export qualifications. The percentage of product defects that appear as a reference for the application of various methods to eliminate defects and thereby reduce product returns (Przystupa, 2019).

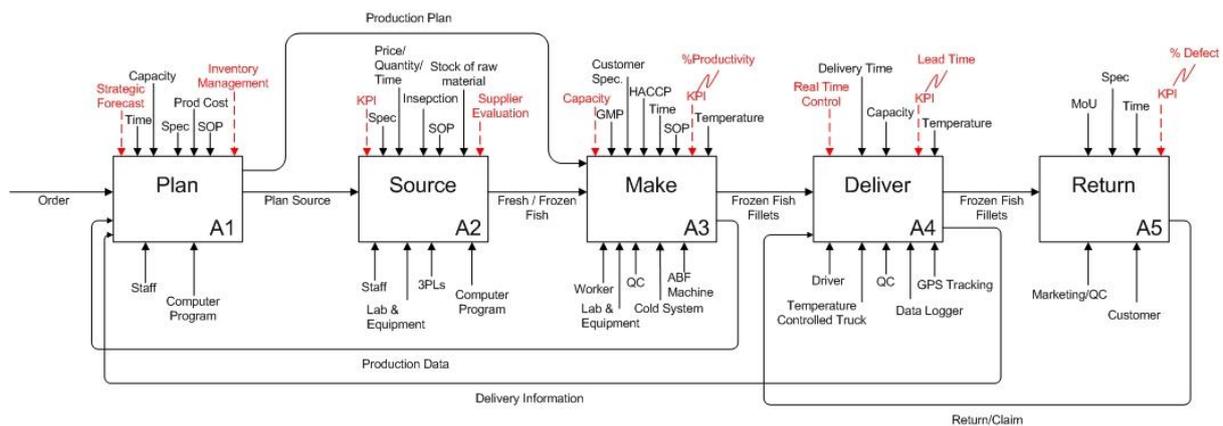


Figure 3. IDEF0 level 1 (production plant level)

### 3.2.3. The business process of frozen tilapia fillets at the make activity in the production department (IDEF0 Level 2)

In IDEF0 level 2, all the activities that occur in the production department (A3 in level 1) are categorised as receiving, processing, freezing, packing and storing. Figure 4 shows the business process in the production department. In the receiving activity, quality checks are performed by quality control staff based on existing operating procedure standards. However, the checks usually depend on the experience of the staff working in this section, so there will be quality differences with other staff. Therefore, the quality standard in the receiving process needs to be of the same quality. The quality of fresh fish as a raw material affects the final product. The longer the storage period prior to freezing, the more likely the quality of the frozen fish will deteriorate (Watanabe et al., 2020).

There is a bottleneck in the vacuum station because it has less capacity than the previous station. Therefore, it is necessary to increase the capacity of the vacuum machine to overcome the bottleneck. In the production department, all processes are under temperature control, but not well implemented. The company should have an ice crusher for the production of ice so that the temperature can be under control. In the processing section, the capacity is also limited due to limited labour. Actually, the Air Blast Freezer (ABF) machine has a capacity of 5 tonnes / batch, but sometimes it is not fulfilled. Product defects often occur in packing activities due to poor handling from workers. Therefore, inspection by supervisors is required in this process. To improve production results, a

number of quality and human resource management techniques, methods or tools can be applied to increase production capacity, volume of products manufactured and production quality (Blaga, 2020). In the storage activity, inventory management is currently carried out using simple spreadsheets and an inventory policy has not been properly implemented. The recommendation that can be made is that there is a need for a stricter inventory policy in order to maintain the availability of products in accordance with the required cold storage temperature.

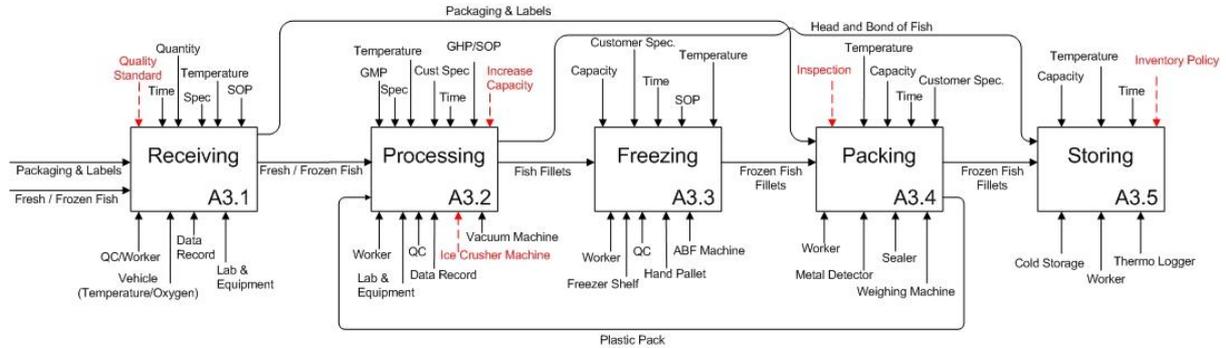


Figure 4. IDEF0 level 2 (make/production department)

### 3.3 Suggestion for improvement

A summary of current problems and suggestions for improvement at the organizational level can be seen in Table 1:

Table 1. Current problems and suggestions for improvement at the organizational level

Stakeholder	Problem	Improvement
Collection Centers	Product quality decrease during storing Lack of traceability at farm level	Implement the cold storage management by using freezer Implement database and traceability system
	Product defect during delivery process	Checking the amount of oxygen and temperature in routine
All Stakeholders	Lack of coordination and information High error of forecasting	Sharing information for all stakeholders Centralized demand forecast

A summary of current problems and suggestions for improvement at the production plant level can be seen in Table 2:

Table 2. Current problems and suggestions for improvement at the production plant level

Activities	Problem	Improvement
Plan	Lack of strategic forecast	Long term demand forecast Use qualitative and quantitative forecast analysis
	Short shortage during rainy season	Improve the inventory management stock
Source	Minimum number of supplier (only from Sleman and Klaten)	Finding another supplier who able to supply fish with good quality in Central Java
	Lack of consistency of fish quality from collection center	Check quality 3 times (harvesting, in the collection center, and before deliver to production plant) Use some KPI to evaluate supplier performance

Activities	Problem	Improvement
Make	Minimum productivity	Increase the capacity by using outsourcing worker
	Lack of worker commitment	Strengthening personal commitment to following SOP and use inspection (in packaging department)
	Imbalance production line (bottleneck in vacuum process) Product defect because of improper handling	Increase the capacity of vacuum machine Training the outsourcing worker and improve the inventory policy in cold storage department
Deliver	Lack of real time tracking and coordination between driver and staff	Check the temperature product by using thermo data logger in routine
	Long lead time for delivery	Collaborate with 3 PLs who has a good performance
Return	No indicator of product defects returned	Use key performance indicators

A summary of current problems and suggestions for improvement at the make activity in the production department can be seen in Table 3:

Table 3. Current problems and suggestions for improvement at the make activity in the production department

Activities	Problem	Improvement
Receiving	Quality standards based solely on staff experience	Maintaining quality through quality standards
Processing	Low capacity of machines	Increase the capacity of the vacuum machine
	Product temperature is not well maintained	Adding ice crusher machine
Packing	Product defects often occur due to poor handling from workers	Inspection by supervisors
Storing	Inventory management has not been implemented properly	Implement a stricter inventory policy

#### 4. CONCLUSIONS

The current supply chain of frozen tilapia fillets was investigated. In this frozen tilapia fillet supply chain, breeders, spreaders, enlargers and collection centres are located in Sleman, Yogyakarta and Klaten, Central Java. Tilapia of consumption size is sent from the collection centre to the production plant in Semarang, Central Java. The products are exported to USA, Europe and some Asian countries using cold chain system. The business process of frozen tilapia fillets is analysed based on IDEF0 level 0 as the organisational level, level 1 as the production plant level and level 2 as the make activity in the production department. We identified the problems that occurred in the main activities and gave the recommendations for improvement. The main problem at the collection centre at the organizational level is the lack of technology in storage and transportation, so it is recommended for the implementation of cold supply chain. There is a lack of coordination between all stakeholders and forecasting has a high error rate, so it is necessary to share information and use appropriate forecasting techniques. The results at the production plant level showed that there was a lack of strategic forecasting and inventory management in the planning activity. In the sourcing activity, the limited

number of suppliers and inconsistent fish quality were the main problems. The lack of implementation of a good material handling and production system was a concern in the making activity. The problem in the delivering activity was the lack of product tracking which results in product returns due to defects. Recommendations for improvement were made for each of the problems in the Activity. At the production department level, quality standards are needed in the receiving process to have the same quality, increasing the capacity of the vacuum machine to overcome the bottleneck, using an ice crusher to produce ice, carrying out inspections to reduce defective products, applying inventory policies to maintain product availability. In this study, there are limitations in collecting some sensitive information due to company confidentiality. We hope that our guidelines can be applied by stakeholders in a frozen tilapia fillet supply chain. Further research can be conducted to identify the problem in more detail and provide an appropriate solution.

## ACKNOWLEDGEMENT

The authors would like to thank the respondents who kindly provided information for this research. We are also grateful to the anonymous reviewers who provided important suggestions to improve the manuscript.

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