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Quality Control of Frozen Fish Based on Fault Tree Analysis (FTA) and Failure Mode and Effect Analysis (FMEA) Methods

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Abstract:
This research conduct in frozen fish supplier based in east Java, Indonesia, namely Biji Sesawi company. Focuses on the issue of improves the quality of frozen fish stored in the Cold Storage. The research method is based on a qualitative research by conducting interviews with quality control and machine operators to analyze historical data from September to November 2021 using Fault Tree Analysis (FTA) and Failure Mode and Effect Analysis (FMEA) tools. The results showed that the dominant type of defect was the change in the surface of the yellow fish with a defect percentage of 21.99% of the 7 types of defects that occurred in frozen fish in accordance with the characteristics determined by the Ministry of Marine Affairs and Fisheries (KKP) of Republic Indonesia. Based on Fault Tree Analysis (FTA), the factors cause the surface of the fish changed into yellow in frozen fish product are the inaccurate application of the FIFO system, and the room temperature level. The suggestions to improves the quality of stored fish are maintain the distance of new product placed in Cold Storage carried out by the maintenance department, which aims to make it easier for employees to take products that are difficult to reach and the duration of products stored. The final results of the research after the implemented method concluded in December, that there was an improves in fish quality by 2.97%, and increases the sales volume and consumer satisfaction.

Keywords: Fault Tree Analysis (FTA), Failure Mode and Effect Analysis (FMEA), cold storage, quality control, qualitative method

INTRODUCTION

Indonesia is well known as a maritime country, because it has abundant natural wealth in the marine sector, one of which is fisheries. The potential income from the fishing industry in Indonesia is very large. Based on production data from the Ministry of Maritime Affairs and Fisheries of Republic Indonesia in 2019 with the total of 6.98 million tons, there is an opportunity for utilization of 3.05 million tons (Mega & Puspa, 2021). Statistics data from the local marine and fisheries service of East Java Province, the coastal fishing port of Muncar, Banyuwangi, East Java area produced a total of 524,695 kg and 999,749 kg of fish in March and April 2019. Meanwhile, in mid-April 2020 it increased dramatically to 1,047,375 kg and 1,192,740 kg, with fish type of Lemuru and Flying species were the most caught. The average price of Lemuru and Flying fish is down 40-50 percent in the current situation. Prices fell as a result of the excess supply of Lemuru and Flying fish compared to market demand. In order to get the lowest price, the company maximizes market conditions situation by buying as many types of Lemuru and Flyings as possible. Noorma Luthfiana, stated that the fishing industry grew by 9.69 percent in the second quarter of 2021, even though the COVID-19 outbreak is still ongoing in Indonesia. This condition is encouraged to increase production in the field of aquaculture and capture fisheries as a result of good meteorological conditions.

Sandra (2021) stated that "Cold Storage is a specially built room with certain temperature conditions, and its main task is to maintain the quality of fish caught by fishermen by freezing the fish caught by fishermen and storing frozen fish. However, if a protein is stored in Cold Storage for a long time, it will start to change some of its protein. There are several techniques for managing quality. In this research, Fault Tree Analysis (FTA) and Failure Mode and Effect Analysis (FMEA) approaches are used.

RESEARCH METHOD

Theoretical Context

1. Frozen Fish Quality

Fish quality is a term that does not only include appearance and freshness, but is also related to food safety (consumption), such as the absence of microorganisms or substances harmful to consumer health (Duarte et al., 2020). Thus, Duarte et al (2020) explain that in general fish quality involves the absence of microbiological and chemical risks and the maintenance of sensory, nutritional, and physicochemical factors (e.g., moisture, pH, color, texture, and macronutrients) in accordance with the stated objectives intended.

2. Control

Purnomo (2004), Mardiono & Laili (2016), defines quality control as a process control activity that involves determining product quality characteristics, comparing them with specifications or requirements, and taking appropriate health action if there is a difference between actual appearance and standard appearance. The goal of quality control is to ensure a high and sustainable quality of goods and services that satisfy customers.

3. Cold Storage

Cold Storage or also known as cold room and frozen storage is a special type of room, where the temperature is kept very low with the help of precision machines and instruments. This is in accordance with the statement of Lu & Liu (2015), which is a cooling facility to create the right humidity and room temperature conditions. Cold Storage can also eliminate the influence of climate, extend the storage period of agricultural, livestock, fishery products, to regulate market supply. In the Cold Storage concept, after the fish is frozen, the fish must be stored at a constant temperature of -23°C (−10°F) or below to maintain a long shelf life and maintain quality. Most fresh fish consist of water.

4. Pareto Diagram (Pareto Analysis)

Pareto diagrams can be used to explain some critical problems by utilizing the 80:20 rule, which states that an 80% improvement is achieved by solving 20% of the most significant problems seen (Yamit, 2010; Purnomo, 2018).

5. Fault Tree Analysis (FTA)

Fault Tree Analysis is a straightforward fault tree analysis approach that can be considered as analytical (Purnomo (2007); Kasad (2018)). A fault tree is a graphical representation of possible parallel and pilot combinations of failures that can lead to previously unexpected experiences. As mentioned earlier, the fault tree model was developed by interviewing management and seeing directly the manufacturing process in the field. The fault tree model was also used to describe the source of the task.

6. Failure Mode and Effect Analysis (FMEA)

There are several definitions of Failure Mode and Effect Analysis as follow:

a) Hanif Nursyahbani, Kartika Puspa Negara (2016): FMEA is a systematic strategy to find and implement problem-solving actions for future processes and products. FMEA is proactive, focusing on prevention, improving workplace safety and increasing customer happiness. FMEA is classified into two types, namely design and process.
b) Chrysler (1994): FMEA is a systematic approach to describe and protect as many modes of system failure as possible. FMEA is used to ascertain the origin and underlying causes of quality problems.
c) Krisnaningsih (2021): FMEA is a way to identify the type of failure that can cause each damage, as well as determine the impact of the failure associated with each damage.
d) Rachman (2016): Failure Mode and Effect Analysis has three main process variables, namely Severity, Occurrence, and Detection. These three procedures are responsible for determining the severity value of the potential failure mode. Based on Ghivaris (2015), the three main factors in FMEA (Failure Mode and Effect Analysis) are as follows:
    i. Severity (Fatal), the severity of determining the possible effects of a failure requires an evaluation of the failure based on its impact. The severity of failure is rated on a scale of 1-10. For example, a number 1 indicates the lowest level of severity (low danger), while a rating of 10 indicates the greatest level of seriousness (high risk).
    ii. Occurrence, refers to the potential causes that will materialize and result in some type of failure throughout the product production process. The occurrence rating is determined on a scale of 1-10. Rank 1 indicates a low frequency of occurrence (not often), while rank 10 indicates a high frequency of occurrence (often).
    iii. Detection, is a technique, test, or analysis used to avoid service, process, or customer failures". When assigning a detection rating, a rating of 1-10 is used. For example, a rating of 1 is the highest level of control that can always identify a failure, while a rating of 10 is the lowest level of control that cannot tell when something went wrong.

7. RPN (Risk Priority Number)

Ghivaris (2015), RPN (Risk Priority Number) or risk priority number is a mathematical product of the severity of the effect, the probability that a cause will result in a failure related to the effect (event), and the ability to detect a failure in the client's future.

RPN = Severity X Occurrence X Detection

RPN is the result of the acquisition of S x O x D, where each tool will have a unique RPN. For the device with the highest RPN, the team must prioritize these factors to take action or make

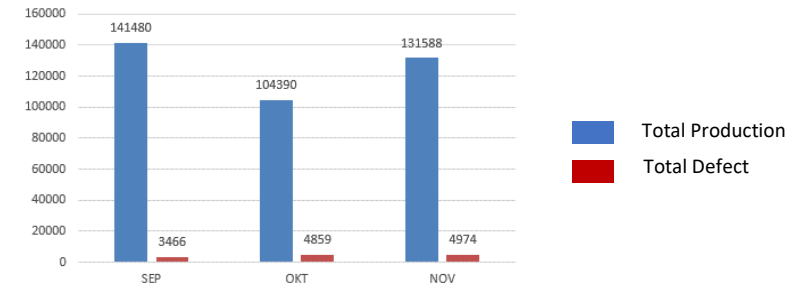
efforts to reduce the amount of risk through corrective maintenance action. The RPN values assigned to each possible concern are then used to compare the identified causes.

IMPLEMENTATION DESIGN

Using a qualitative method based on interviews and supported by the existence of total production data, total product defects data, the results of decreased quality of frozen fish to find factors causing defects in frozen fish products. Primary data sources include direct interviews with the head of the quality control department, which form the basis of Fault Tree Analysis (FTA), group discussions with Quality Control Officers and Machine Operators, which act as the basis for determining severity, occurrence, and detection on FMEA analysis (Failure Mode and Effects Analysis). Sekaran and Bougie (2016), stated that secondary data is information collected through literature studies or as a consequence of collecting data or information from relevant readings and references. The type of data used in this study is includes frozen fish stock data, product data unfit for consumption (defect), as well as company history and description.

RESEARCH RESULTS AND DISCUSSION

In the last 3 years, there has been a declined in the quality of frozen fish. In order to maximizes the result of this research, the researchers took the highest number of total defects in 2021 as in September (2.44%), October (4.65%), and November (3.77%) as follows:

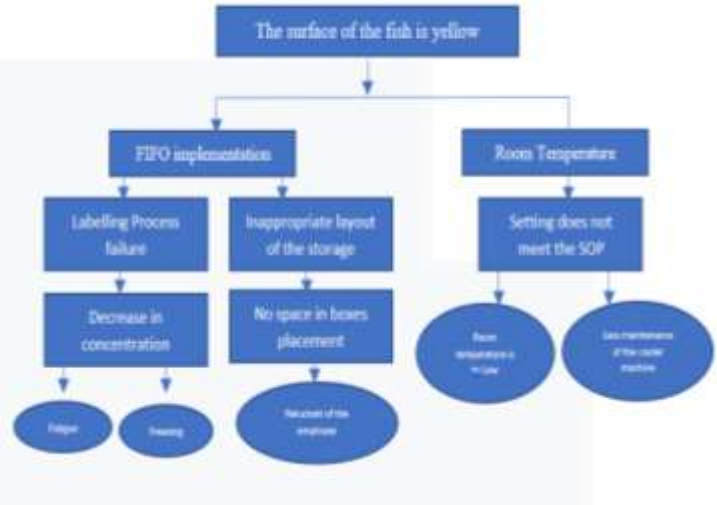


Company's requirement based on interviews with Quality Control Officers, stated that defect number must not exceed 2%. There are several factors that can be considered to see if fish is not suitable for consumption according to the KKP (Ministry of Marine Affairs and Fisheries). The types of defects that occur in fish quality reduction are seven points according to the regulations set by the KKP. The types of defects are: Easily crushed, the surface of the fish is yellow, the eyes are covered with mucus, fishy smell, brown gills, soft structure, fish scales easily come off. To determine the type of product that was most damaged between September and October 2021, the data was processed using a Pareto diagram. According to the data collected from the company, the total number of frozen fish defects in the product is the surface of the fish turn yellow with a defect rate of 21.99%.

Fault Tree Analysis (FTA)

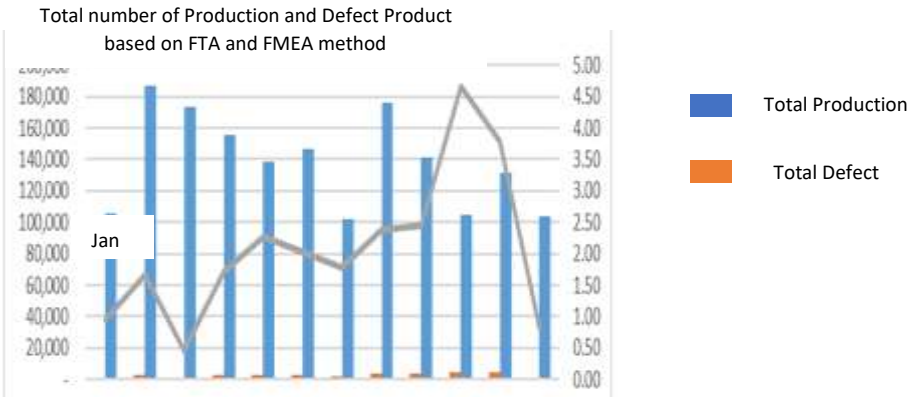
Interview conducted with the QC officers described the situation. The application of the FIFO system in a storage warehouse, especially Cold Storage, is something that needs to be considered, because fish that are too long in cold storage will definitely experience chemical changes due to too long storage. Therefore, to minimize the damage that causes yellowing of fish, it is necessary to apply FIFO where the product that enters must be released earlier. The yellowing of this fish is influenced by several reasons. Human error, happens because workers are careless during the labeling process, such as writing the date of entry and date of exit, resulting in too long fish in the cold storage. This occurred when processing sales data that

does not match the stock. Layout less systemized, happens because employees are reluctant to take fish in Cold Storage, there are fish placements that are very close together so employees are reluctant to take fish that placed in difficult area to reach. Room temperature, happens because the setting that is not in accordance with the standard SOP results in uncontrolled chemical changes in the fish, resulting in yellowing of the fish and unfit for consumption.



Failure Mode and Effect Analysis (FMEA)

Factors from the FMEA (Failure Mode and Effect Analysis) weighting were determined using the results from interviews and discussions. The greatest RPN (Risk Priority Number) value on the yellowing surface of the fish is the employee who is reluctant to release the product with an RPN (Risk Priority Number) value of 168. Based on the results of the analysis, 5W + 1H is carried out by the maintenance department, to adjust the distance between products so that employees can easily take the product so that yellowing does not occur in fish because it is too long in cold storage. With this, it is hoped that the company can prioritize the main factors causing the decline in the quality of frozen fish.



After implementing the recommendations action using the FTA and FMEA methods, data on defective fish products in the company decreased by 2.97%, which means an increase in fish quality.

CONCLUSION

1. After implementing the recommended action in December, there was an increase in fish quality by 2.97%.
2. Resume based on the analysis carried out using FTA (Fault Tree Analysis) the factors due to the yellow surface of the fish on the frozen fish product are the FIFO system application and the room temperature factors.
3. Results of the analysis using a Pareto diagram, the dominant type of defect was found, namely the change in the surface of the fish with a defect percentage of 21.99% of the 7 types of defects that occurred in frozen fish in accordance with the characteristics determined by the KKP.
4. Based on the acquisition of the RPN (Risk Priority Number) value, the largest on the surface of the fish is the employee who is reluctant to issue the product with the RPN (Risk Priority Number) value of 168.
5. Based on the 5W + 1H analysis, the proposed improvement on the surface of the fish that turns yellow is to measure the distance every time a new product is added to the product that is already in Cold Storage carried out by the maintenance department, which aims to make it easier for employees to take products that are difficult to reach, so that the FIFO system can be realized, fish are not too long in cold storage which results in the surface of the fish turning yellow and unfit for consumption.
6. Final analysis using the FTA and FMEA methods, the results are in two categories, the first is improvement in the form of human resources and the second is in the form of machines. It is hoped that the company can review the two categories of factors that affect the quality decline in frozen fish in the Cold Storage.
7. According to the researchers, ideas or actions that businesses can take to prevent and reduce the number of defects can be achieved by reducing the elements that contribute to defects, as follow:

   a. Required shelves or dividers with a minimum of 1 meter to provide a distance between the product that has just been inserted with the goods that are already in the Cold Storage.
   b. Routine check the distance when entering new products with products already in Cold Storage.
   c. Maximizing products with efficient arrangement rather than increasing stock without paying attention to the distance between products so that goods pile up and are difficult to pick up.

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