SUPPLY CHAIN RISK MITIGATION STRATEGY USING SCOR WITH HOR METHOD AT PT. PUTRA JAYA NANAS

Stevani Agatha Yudiantoro[1]
Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia
21032010065@student.upnjatim.com

Farida Pulansari[2]
Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia
farida.ti@upnjatim.ac.id

Abstract

The high consumer demand for processed pineapple fruit drinks increases competitiveness, which requires companies to identify and analyze the risks that exist in each company's supply chain activities. One of the companies engaged in the production of pineapple juice drinks experiences high production demand and several other obstacles that affect the performance of the company that is hampered. This study aims to analyze the supply chain in pineapple juice beverage production activities to identify the risks that occur. The solution was carried out using the SCOR model with the House of Risk (HOR) method. Based on the results of risk identification using the HOR stage 1, 20 risk events were obtained, which were caused by 29 risk agents. Through the calculation of the ARP value, 11 causes of risk are presented, which are input to the next calculation, namely the HOR stage 2. In stage 2, 16 risk mitigation designs were obtained that were able to minimize the risk of occurrence. From the effectiveness value of risk mitigation obtained based on the total effectiveness value and the degree of difficulty, it is determined that the highest value to be the company's priority, is recruiting machine technicians (PA4) of 1361.25, and the lowest value is ensuring that the automatic filling machine always works optimally (PA16).

Keywords: Risk, Mitigation, SCOR, HOR

INTRODUCTION

Indonesia has successfully produced large quantities of pineapple and developed an extensive export network, mainly to the United States, Europe, and Asian markets (Marimin and Muzakki, 2021). Blitar Regency, as one of the largest pineapple producers in East Java, reached a production of 832,904 quintals in 2023, thanks to favorable geographical and climatic conditions (Badan Pusat Statistik, 2023). This encourages local residents not only to sell pineapples but also to innovate in processing them into various products. Despite its great potential for the local economy, the pineapple industry in Indonesia, particularly in Blitar, faces risks that could disrupt the supply chain. With high global demand, industry players need to identify and manage these risks through in-depth analysis and effective mitigation strategies.

PT. Putra Jaya Nanas is a company engaged in processing pineapple fruit into packaged pineapple juice beverage products. This drink is produced in the form of 120 ml and 150 ml cup packaging. This “Segarrr” Pineapple Juice Drink is marketed from the Blitar area to Solo City. The production of this “Segarrr” drink has reached hundreds of thousands per year. During the establishment of the company, many obstacles were faced to be able to meet market demand. Based on interviews that have been conducted, the company has product defects during the production process. In addition, several times, getting inconsistent quality of raw materials. So that the company is unable to meet the high demand from consumers. The number of raw materials obtained is often insufficient due to the unstable management of raw material sources, which affects production activities. With high consumer demand, it certainly has an impact on the risk of delays in delivering goods to consumers. The company's non-optimality in meeting demand is caused by raw materials which are agricultural products. Agricultural products have special characteristics that make risk management for agribusiness supply chains more complicated than other manufacturing supply chains. These characteristics are seasonality, biological aspects of the production cycle, supply spikes, and perishability (Anugerah, et al., 2021). This is very risky for supply chain activities that can result in bottlenecks in the production process.

In this study, risk identification and risk mitigation design were carried out during supply chain activities. The purpose of identifying risk mitigation is to find out the risks that become obstacles to supply chain activities and mitigation strategies that companies can carry out so as to increase productivity. This research determines risk mitigation strategies using the House of Risk (HOR) method using the SCOR Model. House of Risk (HOR) is an approach that emphasizes the importance of preventive activities in risk management. This is done by identifying and reducing the likelihood of risk agents that can trigger the event. The HOR approach also describes how closely the relationship between risk events and related risk agents is quantitatively (Hamka et al., 2021). House of Risk (HOR) is the result of combining two concepts of methods, namely FMEA (Failure Mode and Effect Analysis) and House of Quality (HOQ), into simpler quantitative data processing to state risks based on their priority (Magdalena and Vannie, 2019). HOR 1 to explain the ranking of each risk cause based on the aggregate risk potential (Paillin and Tupan, 2021). The assessment is carried out with a questionnaire used as an Aggregate Risk Potential (ARP) value, which is then used to prioritize risk agents as the basis for mitigation initiatives (Perdana, 2020). The House of Risk Stage 2 calculation shows the order of risk management based on the ETD value, with the highest value as a priority. After obtaining management priorities based on the level of implementation effectiveness, an assessment of severity and occurrence rates is carried out by experts based on the risk agents that have been identified in the management strategy. This assessment aims to remap the risk conditions that have been created by the management prioritization strategy and is carried out by experts through focus group discussions (Oktavera, et al., 2022).

Several studies that have been conducted previously discuss risk mitigation using the House of Risk (HOR). Research by Marimin and Muzakki, (2021) examined agroindustry supply chain risks at PT Great Giant Pineapple Co using parameters including forecasting, machine maintenance, product quality and transportation. Another study by Oktavera, et al. (2022) conducted risk mitigation using weather, product quality and environment parameters. Research by Padhil, et al. (2021) discusses supply chain risks in the chocolate industry using raw material quality, coordination, and maintenance parameters. The novelty of this research lies in the integration of four key parameters: forecasting, raw material quality, environment, and product quality, which are designed based on the specific problem identification of the company and validated by previous studies. This approach provides a new perspective in addressing operational challenges by combining predictive, qualitative, and contextual aspects in a comprehensive manner.

REVIEW OF LITERATURE

Supply Chain

Supply chain is an integrated process in which various entities work together to obtain raw materials, process them into finished products, and distribute them to retailers and customers. In addition to being a combination of supplier, manufacturing, customer, and delivery processes, the supply chain also functions as a system through which the organization delivers its goods and services to consumers (Haudi et al., 2022). The supply chain includes a series of activities in a network of facilities and distribution options that involve interactions between suppliers, companies, manufacturers, distributors, and consumers. This process involves various parties, such as manufacturers, warehouse managers, vendors, transportation service providers, distributors, and retailers. Therefore, the supply chain is an important component that connects producers, suppliers, distributors, and consumers. The purpose of the supply chain is to support the course of business activities. If one of the supply chain components is not carried out, for example, there is no transportation of product results, then the company can be said to no longer operate.

Supply Chain Operations Reference (SCOR)

Supply Chain Operation Reference (SCOR) was developed by a professional organization, the Supply Chain Council (SCC), in 1996. The process-based reference model that is often used in supply chain performance measurement is the Supply Chain Operations Reference (SCOR) model. The SCOR model is well known for connecting business processes, performance metrics, standard practices, and people skills into an integrated structure. SCOR is regularly updated to reflect changes in supply chain business processes. The SCOR model consists of standardized supply chain processes, attributes, and standardized performance indicators, practices, and standardized people skills. The processes in the SCPR Model consist of plan, source, make, deliver, and return.

House of Risk

The House of Risk (HOR) model is one of the analytical approaches often applied in supply chain management to identify, analyze, and manage risks. Meanwhile, the HOQ method, adapted from QFD, is utilized in the process of designing risk mitigation strategies. With this approach, HOR enables a more systematic identification of risk sources while guiding devising more effective risk elimination or reduction strategies, thereby supporting process optimization in the supply chain (Pujawan and Geraldin, 2009). According to Irawan (2019), the House of Risk (HOR) phase 1 is the initial stage that aims to identify risk events and the agents that cause them. House of Risk (HOR) phase 2 is the design of mitigation strategies to carry out risk treatment of risk agents that have been identified and some at priority risk levels. The output results of the House of Risk (HOR) phase 1 will be used as input to the House of Risk (HOR) phase 2.

Pareto Chart

Pareto diagrams aim to show the main dominant problems, stating the comparison of each problem, showing the level of improvement after corrective action is taken, and showing the comparison of each problem (Liddin & Pulansari, 2024). According to Magdalena et al. (2019), based on the Pareto 80:20 principle, problems that contribute up to 80% of the total impact are considered the top priority to solve. This diagram is in the form of a bar graph that presents data based on the order of the number of occurrences, starting from the most frequent problems to the least frequent ones. On the graph, this order is displayed from the highest bar on the left side to the lowest bar on the right side. In its application, Pareto Diagrams are very effective in determining and identifying the priority problems that need to be solved first.

RESEARCH METHOD

Data analysis in this study uses the House of Risk (HOR) method using the SCOR model. The data used in this study are primary data obtained directly from the company. This research data source is obtained through interviews, questionnaires, and brainstorming discussions with the company. In this study, data is needed regarding production demand data, production target data, production schedule data, data on the number of employees, defective product data, production capacity data, product delivery schedule data, and data on the number of products returned. The questionnaire is filled in by the company to get the severity, occurrence, and correlation values. Interviews and discussions with the company aim to find out the condition of the company and adjust the results of the risk mitigation strategy plan to the company.

RESULTS AND DISCUSSION

Business Activity Mapping and Risk Event Identification Based on the SCOR Model

In the SCOR model concept, there are 5 core activities of the entire supply chain process. The five core processes consist of plan, source, make, deliver, and return. From the results of mapping supply chain activities in the company using the SCOR model concept, sub-processes of each activity and details of activities that run in the company in carrying out all supply chain activities are obtained. From the supply chain activities that have been described, risk identification is carried out. Risk identification activities here aim to identify the potential to harm or adversely affect the company in each supply chain activity.

Table 1.
Identification of Risk Events Based on the SCOR Model

No	Major Processes	Sub Processes	Activities	Code	Risk Event
1	Plan	Raw Material Planning	Planning the needs of the production process	E1	Lack of raw materials to perform production process
		Production Schedule Planning	Plan the production process schedule	E2	Sudden change in production schedule
		Product Request Management	Managing product demand with production capacity	E3	High product demand does not match production capacity
2	Source	Procurement Process	Determination of raw material suppliers	E4	Dependence on one supplier
			Determination of raw material delivery schedule from suppliers	E5	Delays in raw material delivery
			Checking the quality of incoming raw materials	E6	Raw material quality does not match the order
3	Make	Production Machine Preparation Process	Checking production machines	E7	Machine has a sudden breakdown
		Production Process	Pineapple peeling and cutting process	E8	Work accident occurs
			Water Boiling	E9	Inappropriate water volume
No	**Major Processes**	**Sub Processes**	**Activities**	**Code**	**Risk Event**
3	Make	Production Process	Pineapple Boiling	E10	Boiling temperature above required
			Filling	E11	Content exceeds standard
				E12	Leakage occurs during filling
			Sealing	E13	Seal is not sealed
			Checking	E14	Discoloration of the product
			Packaging	E15	Defective cardboard packaging

		Finished Product Storage Process	Storage of finished products in the warehouse	E16	Decreased product quality
4	Delivery	Delivery Planning	Determination of the delivery schedule and transportation	E17	Delayed delivery of products to customers
				E18	Transportation capacity and product delivery demand do not match
		Delivery Process	Checking of the delivered products	E19	Product damage during shipping
5	Return	Defective Product Return Process	Returns and handling of returned products	E20	Long handling of product returns

Source: Data Processing Results

The results of the identification of risk events are 20 risk events that occur in the company's supply chain activities. Based on the results of the identification of risk events that have been compiled, the identification of risk agents from each risk event is carried out. The results of the identification of risk causes are 29 risk agents that occur in the company's supply chain activities.

Table 2.
Risk Agent Based on Risk Event

Code	Risk Event	Code	Risk Agent
E1	Lack of raw materials to carry out the production process	A1	Delayed delivery by *supplier*
		A2	Differences in the quality of raw materials delivered
E2	Sudden changes in the production process schedule	A3	Production machines that have not been repaired
		A4	Unavailability of raw materials
E3	Product demand does not match production capacity	A5	Insufficient labor
Code	**Risk Event**	**Code**	**Risk Agent**
E3	Product demand does not match production capacity	A6	Significant increase in product demand
E4	Dependence on one *supplier*	A7	Does not specify other *suppliers* with the same quality
E5	Delays in raw material delivery	A8	There are obstacles during the trip
E6	Raw material quality does not match the order	A9	*The supplier* is not careful
		A10	There is a misunderstanding with the *supplier*
E7	The machine has a sudden breakdown	A11	Using out-of-town *service*
		A12	No *maintenance* schedule
E8	A work accident occurs	A13	Less conscientious employees

		A14	Did not conduct OHS socialization to employees
E9	Inappropriate water volume	A15	Not checking regularly
E10	The boiling temperature is not as required	A16	Sudden shutdown of the boiling machine
E11	Content exceeds standard	A17	The filling machine is not working optimally
E12	Leakage occurs during filling	A18	Product filling exceeds packaging
E13	Seal is not sealed	A19	The engine is not at the proper temperature
		A20	Product filling exceeds packaging
E14	Discoloration of the product	A21	The worker's hand hits the lip of the package
E15	Defective cardboard packaging	A22	Packaging quality is not in line with company specifications
E16	Decreased product quality	A23	The production process does not run according to SOP
		A24	Employee error in product storage
E17	Delayed delivery of products to customers	A25	Insufficient transportation capacity
E18	Transportation capacity and product delivery demand do not match	A26	Transportation shortage
Code	**Risk Event**	**Code**	**Risk Agent**
E19	Product damage during shipping	A27	Employee carelessness on the road
		A28	Leakage during travel
E20	Long handling of product returns	A29	The number of other orders that must be prioritized

Source: Data Processing Results

House of Risk Analysis Phase I

From the results of the identification of risk events and risk agents that have been compiled, a severity assessment is carried out for risk events and the occurrence of risk agents. Severity is used to determine the severity of each risk event that has been previously identified in each company's supply chain activities using the SCOR model. Severity assessment is based on how much impact the risk event has on each company's supply chain activities. In this study, a scale of 1-5 is used to determine the severity value carried out by the company.

Table 3.
Likert Scale Severity Score

Scale	Description
1	Very little effect on system performance
2	Little effect on system performance
3	Sufficient influence on system performance
4	Great impact on system performance
5	Very big impact on system performance

Source : Rizqi et.al. (2023)

The purpose of determining the occurrence value is to determine the level of occurrence of each risk because that has been previously identified in each of the company's supply chain activities using the SCOR model. In this study, a scale of 1-5 is used to determine the occurrence value carried out by the company.

Table 4.
Likert Scale Occurrence Value

Scale	Description
1	Risk-causing occurrences are rare
2	Occurrence of risk causes sometimes occurs
3	Possible occurrence of risk causes
4	Risk-causing occurrences are highly likely
5	Risk-causing events are almost certain to occur

Source : Rizqi et.al. (2023)

To get the severity and occurrence values, a questionnaire was distributed and filled out by company staff. The following are the results of the average severity and occurrence values:

Table 5.
Severity and Occurrence Value

Code	Risk Event	Severity	Code	Risk Agent	Occurrence
E1	Lack of raw materials to carry out the production process	4	A1	Delayed delivery by the supplier	3
			A2	Differences in the quality of raw materials delivered	2
E2	Sudden change in production schedule	4	A3	Production machines that have not been repaired	4
			A4	Unavailability of raw materials	1
E3	Product demand does not match production capacity	5	A5	Insufficient labor	3
			A6	Significant increase in product demand	3
E4	Dependence on one *supplier*	3	A7	Does not specify other suppliers with the same quality	2
E5	Delays in raw material delivery	4	A8	There are obstacles during the trip	2
E6	Raw material quality does not match the order	4	A9	The supplier is not careful	2

Code	Risk Event	Severity	Code	Risk Agent	Occurrence
E6	Raw material quality does not match the order	4	A10	Misunderstanding with the *supplier*	2
E7	The machine has a sudden breakdown	5	A11	Using services out-of-town *service*	5
		5	A12	No schedule *maintenance*	4
E8	A work accident occurs	4	A13	Less conscientious employees	3
			A14	Did not conduct OHS socialization to employees	3
E9	Inappropriate water volume	4	A15	Not checking regularly	2
E10	The boiling temperature is not as required	2	A16	Sudden shutdown of the boiling machine	2
E11	Content exceeds standard	4	A17	The filling machine is not working optimally	2
E12	Leakage occurs during filling	3	A18	Product filling exceeds packaging	2
E13	Seal is not tightly closed	5	A19	Engine not at proper temperature	2
E13	Seal is not tightly closed	5	A20	Product filling exceeds packaging	3
E14	Discoloration of the product	5	A21	Worker's hand hits the lip of the package	3
E15	Defective cardboard packaging	3	A22	Packaging quality is not in line with company specifications	1
E16	Decreased product quality	3	A23	Production process does not run according to SOP	1
			A24	Employee error in product storage	2
E17	Delayed delivery of products to customers	4	A25	Insufficient transportation capacity	2
E18	Transportation capacity and product delivery demand do not match	2	A26	Transportation shortage	2

Code	Risk Event	Severity	Code	Risk Agent	Occurrence
E19	Product damage during shipping	4	A27	Employee carelessness on the road	2
E19	Product damage during shipping	4	A28	Leakage during travel	3
E20	Long handling of product returns	3	A29	The number of other orders that must be prioritized	4

Source: Data Processing Results

Based on the correlation value between risk events and risk agents obtained through questionnaire results with a predetermined scale, the calculation of the Aggregate Risk Potential (ARP) value is carried out. The calculation of the Aggregate Risk Potential (ARP) value aims to determine the priority of the cause of the risk that is the main focus by the company to be handled. The following table below is the result of the calculation of the Aggregate Risk Potential (ARP) value of each risk cause that has been sorted according to the highest priority.

Table 6.
ARP Value Processing Result

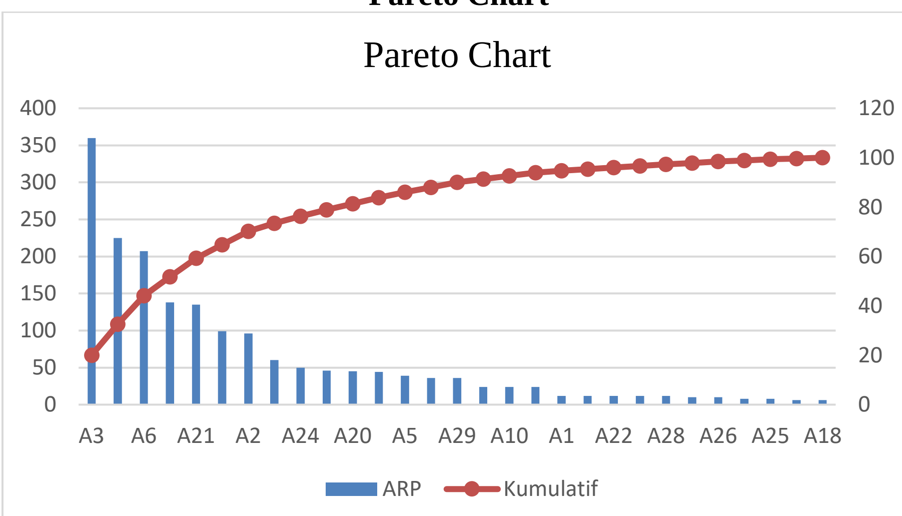
Rank	Code	Risk Agent	ARP
1	A3	Production machines that have not been repaired	360
2	A11	Using out-of-town *service*	225
3	A6	Significant increase in product demand	207
4	A8	There are obstacles during the trip	138
5	A21	The worker's hand hits the lip of the package	135
6	A13	Less conscientious employees	99
7	A2	Differences in the quality of raw materials delivered	96
8	A12	No *maintenance* schedule	60
9	A24	Employee carelessness	50
10	A15	Not checking regularly	46
11	A20	Product filling exceeds packaging	45
12	A4	Unavailability of raw materials	44
13	A5	Insufficient labor	39
14	A14	Did not conduct OHS socialization to employees	36
15	A29	The number of other orders that must be prioritized	36
16	A9	*The supplier* is not careful	24
17	A10	Misunderstanding with the *supplier*	24
18	A27	Employee negligence on the road	24
19	A1	Delayed delivery by *supplier*	12

20	A16	Sudden shutdown of the boiling machine	12
21	A22	Packaging quality is not in line with company specifications	12
22	A23	Production process does not run according to SOP	12
23	A28	Leakage during travel	12
24	A19	Engine not at proper temperature	10
25	A26	Transportation shortage	10
26	A17	Automatic machines do not work optimally	8
27	A25	Insufficient transportation capacity	8
28	A7	Does not specify other *suppliers* with the same quality	6
29	A18	Product filling exceeds packaging	6

Source: Data Processing Results

At this stage, risk ranking will be carried out. This risk ranking is done by determining several risk agents that have the highest occurrence rate. The determination is made using the concept of Pareto diagrams. According to Magdalena (2019), in accordance with the principle of the Pareto diagram, namely 80%: 20%, the priority problem to be solved is the risk with a cumulative percentage of up to 80% of the ranking of the ARP value of each risk, from the largest to the smallest. The cause of the risk is to be mitigated based on the ARP value using a Pareto diagram. The following is a Pareto diagram for each risk agent.

Figure 1.
Pareto Chart



The Pareto diagram above shows the ARP value and the cumulative value of each risk agent. The highest risk agent, production machinery that has not been repaired (A3), has an ARP value of 360 with a percentage of 20%. The risk agent with the lowest ARP value is product filling exceeding packaging (A18), has an ARP value of 6 with a percentage of 0.33%.

Table 7.
Determination of Risk Mitigation

Rank	Code	Risk Agent	ARP	Percentage	Cumulative

1	A3	Production machines that have not been repaired	360	20,04	20,04
2	A11	Using out-of-town service	225	12,53	32,57
Rank	**Code**	**Risk Agent**	**ARP**	**Percentage**	**Cumulative**
3	A6	Significant increase in product demand	207	11,53	44,10
4	A8	There are obstacles during the trip	138	7,68	51,78
5	A21	The worker's hand hits the lip of the package	135	7,52	59,30
6	A13	Less conscientious employees	99	5,51	64,81
7	A2	Differences in the quality of raw materials delivered	96	5,35	70,16
8	A12	No maintenance schedule	60	3,34	73,50
9	A24	Employee carelessness	50	2,78	76,28
10	A15	Not checking regularly	46	2,56	78,84
11	A20	Product filling exceeds packaging	45	2,51	81,35

Source: Data Processing Results

From the table above, it can be seen that there are 11 risk agents with a cumulative value of 80%. These risk agents are the top priority in solving the company's problems. With the concept of Pareto diagrams, the resolution of these 11 risks will have a significant impact. Some of the risk agents above are inputs for the next resolution method, namely the House of Risk (HOR) stage 2. In the House of Risk (HOR) stage 2, a design will be made to handle the risks obtained from the results of House of Risk (HOR) stage 1.

House of Risk Analysis Phase II

The initial stage of completing the House of Risk (HOR) stage 2 method is the design of mitigation strategies. The risk agent has been determined in the final result of the House of Risk (HOR) stage 1 based on the risk agent that has the highest ARP value. This determination is based on the Pareto concept. From each risk agent, the mitigation strategy design will then be determined. Each risk agent can be designed with one mitigation strategy or more.

Table 8.
Determination of Risk Mitigation

Code	Risk agent	Preventive action
A3	Production machines that have not been repaired	Perform routine checks and supervision of production machinery
		Improve coordination between machine operators and the general manager
A11	Using a *service* out of town	Establish a machine service that is close to the production site
		Recruit machine technicians
Code	**Risk agent**	**Preventive action**

A6	Significant increase in product demand	Conduct production capacity planning
A8	There are obstacles during the trip	Make an agreement on late fees
A21	The worker's hand hits the lip of the package	Improve worker supervision of applicable SOPs
		Procure a direct press machine
A13	Less conscientious employees	Conduct a briefing every time you start production activities.
		Conduct regular OHS training for employees
A2	Differences in the quality of raw materials delivered	Make an MOU regarding the quality, price, and delivery schedule of raw materials
A12	No schedule *maintenance*	Create a routine maintenance schedule
A12	No schedule *maintenance*	Create maintenance check sheets for each production machine
A24	Employee carelessness	Conduct an agreement on performance evaluation for all employees
A15	Not checking regularly	Establish inspection teams that focus on core production processes
A20	Product filling exceeds packaging	Ensure the automatic filling machine is always working optimally

Source: Data Processing Results

The correlation assessment stage between the design of mitigation strategies and risk agents has been carried out, followed by the calculation of the Total Effectiveness of Action (TEk). The Total Effectiveness of Action (TEk) value is obtained through the following formula:

$$\text{TEk}=\sum ARPiEjk$$

Information:
Tek : Total effectivity
ARPj : *Aggregate Risk Potential*
Ejk : Risk Event Identification

The next stage is weighting the Difficulty of Performing Action (Dk) value. This weighting aims to determine the magnitude of the difficulty value to be implemented in the company from each mitigation strategy design. The Difficulty of Performing Action (Dk) value is obtained through the degree of difficulty rating scale.

The next stage is the calculation of the Effectiveness to Difficulty of Ratio (ETDk) value. The Effectiveness to Difficulty of Ratio (ETDk) value states the ratio between the effectiveness value of mitigation actions and the difficulty level of each mitigation action. The calculation of the Effectiveness to Difficulty of Ratio (ETDk) value is based on the formula:

$$\text{ETDk} = \text{TEk} / \text{Dk}$$

Information:

ETDk : Effectiveness to the difficulty of ration
Tek : Total effectivity
Dk : The Degree of difficulty

Table 9.
Risk Mitigation Value Processing Results

Code	Preventive Action	TEk	Dk	ETDk
PA1	Perform routine checks and supervision of production machinery	3975	3	1325
PA2	Improve coordination between machine operators and general admin	3420	3	1140
PA3	Establish a machine service that is close to the production site	3105	4	776,25
PA4	Recruit machine technicians	5445	4	1361,25
PA5	Conduct production capacity planning	1863	3	621
PA6	Make an agreement on late fees	1242	4	310,5
PA7	Improve worker supervision of applicable SOPs	1662	3	554
PA8	Procure a direct press machine	1215	5	243
PA9	Conduct a briefing every time you start production activities.	1314	3	438
PA10	Conduct regular OHS training for employees	891	3	297
PA11	Make an MOU regarding the quality, price, and delivery schedule of raw materials	864	4	216
Code	**Preventive Action**	**TEk**	**Dk**	**ETDk**
PA12	Create a routine maintenance schedule	540	3	180
PA13	Create maintenance check sheets for each production machine	1620	3	540
PA14	Conduct an agreement on performance evaluation for all employees	747	4	186,75
PA15	Establish inspection teams that focus on core production processes	1116	4	279
PA16	Ensure automotive filling machines are always working optimally	405	3	135

Source: Data Processing Results

Based on the table above, the results of the preventive action ranking are obtained. This ranking is determined by the value of the Effectiveness to Difficulty of Ratio (ETDk). The greater the Effectiveness to Difficulty of Ratio (ETDk) value, the greater the influence on all supply chain activities.

CONCLUSION

The most effective mitigation action is the recruitment of machine technicians, which is proposed to reduce the risk of machine breakdowns and speed up the repair process, making the company's operations more efficient. By having in-house machine technicians, the company can quickly respond to machine breakdowns, minimizing production downtime.

The presence of these technicians also strengthens the company's risk management by enabling in-house repairs, which improves control over operational schedules and costs. Recruitment of competent technicians and a consistent maintenance program help reduce the risk of sudden breakdowns, resulting in more effective and sustainable operations. Future research is recommended to expand the scope of risk by adding external risk aspects, such as government policies related to the sustainability of the production process and weather factors that affect raw materials. To increase the contribution of research, the object of study can also be extended to other industrial sectors, such as manufacturing, logistics, or agribusiness, to understand the characteristics of risks in different types of supply chains.

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