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Risk Identification and Mitigation in the Halal Black Tea Orthodox Supply Chain Using SCOR and House of Risk

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ABSTRACT

The plantation sector such as tea has a complex supply chain. The production process that takes place at PTPN IV Tobasari Tea Unit is not free from various problems. Delays in the raw material processing process often occur due to raw materials not arriving according to schedule. Delays are supported by disruptions to processing machines that can hinder or even stop the production process. Therefore, it is necessary to design mitigation actions to minimize and prevent risks that occur. This study aims to identify risk-causing factors using the Supply Chain Operation Reference (SCOR) and formulate effective risk mitigation policies based on priority risk agents using the House of Risk (HOR) approach. The results of risk identification at House of Risk showed that there were 21 risk events with 4 priority risk agents where the cumulative frequency value of Aggregate Risk Potential (ARP) was 76.82%. Effective and easy mitigation actions based on the Effectiveness to Difficulty value are to conduct analysis and evaluation of employee performance. These findings provide practical implications for improving supply chain resilience in the tea industry, particularly in addressing delays and machine failures through targeted risk mitigation strategies.

Keywords: Supply Chain Risk Management, Halal Black Tea Orthodox Production, SCOR Model, House of Risk (HOR), Risk Mitigation Strategy

ABSTRAK

Sektor perkebunan seperti teh memiliki rantai pasok yang kompleks. Proses produksi yang berlangsung di Unit Teh Halal PTPN IV Tobasari tidak lepas dari berbagai permasalahan. Keterlambatan proses pengolahan bahan baku sering terjadi dikarenakan bahan baku tidak datang sesuai jadwal. Keterlambatan tersebut didukung oleh adanya gangguan pada mesin pengolah yang dapat menghambat atau bahkan menghentikan proses produksi. Oleh karena itu, perlu adanya perancangan tindakan mitigasi untuk meminimalisir dan mencegah risiko yang terjadi. Penelitian ini bertujuan untuk mengidentifikasi faktor penyebab risiko menggunakan Supply Chain Operation Reference (SCOR) dan merumuskan kebijakan mitigasi risiko yang efektif berdasarkan agen risiko prioritas dengan pendekatan House of Risk (HOR). Hasil identifikasi risiko pada House of Risk menunjukkan terdapat 21 kejadian risiko dengan 4 agen risiko prioritas dimana nilai frekuensi kumulatif Aggregate Risk Potential (ARP) sebesar 76,82%. Tindakan mitigasi yang efektif dan mudah berdasarkan nilai Effectiveness to Difficulty adalah dengan melakukan analisis dan evaluasi kinerja karyawan. Temuan ini memberikan implikasi praktis untuk meningkatkan ketahanan rantai pasokan dalam industri teh, khususnya dalam mengatasi penundaan dan kegagalan mesin melalui strategi mitigasi risiko yang ditargetkan.

Kata kunci: Manajemen Risiko Rantai Pasok, Produksi Teh Hitam Ortodoks, Model SCOR, House of Risk (HOR), Strategi Mitigasi Risiko

1. Introduction

In the era of globalization and increasingly tight competition, supply chain management is the main key to maintaining the sustainability of company operations. The supply chain is a network of companies that work

together to produce and distribute products to customers [1]. Companies must have a supply chain model that is in accordance with strategic issues and customer needs to face current business conditions [2]. An efficient supply chain not only allows companies to optimize production and distribution processes, but also customer satisfaction and competitiveness in the market. The complexity of the various processes in the supply chain requires good management support. However, in reality, supply chain management is not an easy task because each stage in the supply chain flow has the potential to cause detrimental risks [3]. Risk is a symptom that can cause uncertainty about the occurrence of an event within a certain period of time where small or large losses can occur that affect the survival of a company from the event [4].

Manufacturing companies have a complex supply chain flow [3]. One of them is a tea processing company. Tea is one of the mainstay commodities for the development of the Indonesian economy because it is an export commodity that is the main source of foreign exchange for the country along with oil and gas [5]. PTPN IV Tobasari Tea Unit is a tea plantation company that has a wide supply chain covering various stages, from processing agricultural products to distribution to local markets and exports to Asian, African, Australian, American, and European countries. Supply chain management at PTPN IV Tobasari Tea Unit begins with the flow of raw materials, namely wet tea leaves with a daily processing capacity of 55 tons originating from the Sidamanik and Tobasari tea plantations.

One of the problems that often occurs is the delay in processing due to the late arrival of wet tea leaves as raw materials. Wet tea leaves must go through a wilting process before being processed using a machine. The process of wilting wet tea leaves takes quite a long time, which is around 16-18 hours. The delay in the wilting process of wet tea leaves directly affects the next processing schedule. At the rolling station, the delay is not only caused by the late wilting process, but is also supported by the indiscipline of workers in moving the rolled wilted tea leaves from one machine to another. Delays in rolling wilted tea leaves continue to occur significantly every month, with the average percentage of delays reaching 43.07% in 2023. These delays ultimately impact subsequent stations which become late in their respective processing processes.

In addition to delays at the wilting and rolling stations, machine damage has a major impact on delays. A machine that is experiencing problems can hinder or even stop the production process because there is a delay in repairing the machine. Delays in the production process at one station will disrupt the process at other stations because they do not receive input from the previous station.

Activities in the supply chain have the potential to face various risks. If the company does not comprehensively calculate the risks and their impacts on the evaluation of the company's performance, the results obtained may not be optimal. The emergence of risks in various supply chain processes can be minimized by analyzing supply chain risk management. This analysis aims to identify possible sources or risk agents and risk events in each activity and their impacts. In addition, it also involves determining risk mitigation steps to reduce the possibility of recurrence of risks and their impacts [6]. Therefore, analysis of risks in the supply chain of Halal Black Tea production process at PTPN IV Teh Tobasari Unit is very important. The purpose of this study is to identify risk factors and formulate effective risk mitigation actions based on priority risk agents. The appropriate approach to the problem is to conduct a risk analysis of the supply chain of the Halal Black Tea production process based on the SCOR (Supply Chain Operation Reference) method to map the process by identifying activities that occur in the company's supply chain [7] and continued with the House of Risk (HOR) to map failures and risks that may occur from each supply chain activity that has been ignored so far, and design prevention proposals to minimize the identified risk agents [8]. Studies related to supply chain practices in the food industry, including the halal approach, show the need for comprehensive risk mapping and quality control [15].

However, previous studies focusing on supply chain risk management in Indonesia's tea industry remain limited, particularly those employing an integrated approach such as SCOR and the House of Risk. Therefore, this study contributes to filling this gap by providing a systematic framework for identifying risks and designing mitigation strategies in the tea plantation sector.

2. Methodology

This type of research is exploratory descriptive research. Exploratory descriptive research aims to gain a solid, clear and complete understanding of a particular phenomenon that is of concern to the research [9]. This research will explore the problems that occur in the supply chain of the Halal Black Tea production process

and the risks that impact the supply chain and will be followed by an analysis of risk mitigation actions against the problems that arise at PT Perkebunan Nusantara IV Teh Tobasari Unit.

The data sources collected are divided into 2, namely primary data and secondary data. Primary data were collected through interviews, observations, and questionnaires. The primary data collected were mapping of supply chain activities based on SCOR, assessment of risk events (severity), assessment of risk agents (occurrence), assessment of the level of correlation between risk events and risk agents, assessment of the level of correlation between risk agents and risk mitigation, and assessment of the level of difficulty of risk mitigation. Secondary data were collected through literature studies that were relevant to the discussion in the research.

The population in this study were all leaders and employees who were responsible for the orthodox Halal Black Tea production process at PTPN IV Teh Tobasari Unit. There are 3 leaders and all employees totaling 116 people. The sampling technique used is purposive sampling where this technique uses certain people or special target groups who have knowledge, experience and positions that make them sources of data or information [9]. The selection criteria for respondents included individuals with a minimum of two years of experience in orthodox Halal Black Tea production and direct involvement in production, supervision, or supply chain management. This criterion ensures that the collected data is derived from knowledgeable sources with hands-on experience in operational processes and risks. Therefore, the data sources of this study are Technical and Processing Assistants, Withering Foremen, Rolling Foremen, Enzymatic Oxidation Foremen, Drying Foremen, Sorting Foremen, and Packing Foremen. One limitation of this method is the potential subjectivity in risk assessment due to reliance on respondents' perceptions and experiences. Additionally, the use of purposive sampling may limit the generalizability of the findings to the broader tea industry population.

3. Results and Discussion

3.1. Identification of Risk Events and Risk Agents

This study began by identifying risk events that have a negative impact on the supply chain flow using the SCOR framework [2]. Supply Chain Operations Reference (SCOR) is a reference model for supply chain operations that integrates three core management elements, namely business process redesign, benchmarking, and process measurement into a cross-functional supply chain framework. Supply Chain Operations Reference (SCOR) describes the supply chain process based on five main processes, namely plan, source, make, delivery, and return [1].

The identification process is carried out by means of observation and interviews with informants. Risk assessment is carried out by filling out a closed questionnaire by selected respondents. Identification of risk events aims to see all risk events that may arise in supply chain activities that are compiled based on SCOR. Risk agents are things that are the root cause of risk events. Risk events can be caused by one or more risk agents. Risk event assessment is carried out by assessing the severity level caused by the risk event. Risk agent assessment is carried out by assessing the probability (occurrence) or how often the risk agent occurs. The severity and occurrence assessment scales are based on the criteria of a scale of 1-10 [7]

3.2. Identification of Correlation of Risk Events with Risk Agents

Correlation assessment is carried out to see the relationship or connection between risk events and risk agents. The assessment uses scores of 0, 1, 3, 9 for no correlation, low correlation, moderate correlation, and high correlation [8].

3.3. House of Risk I

In House of Risk I, input data is required in the form of severity assessment, occurrence assessment, and correlation assessment between risk events and risk agents to calculate Aggregate Risk Potential (ARP) in determining the priority of risk agents that must be handled first. Priority is determined based on the largest ARP value. An example of ARP calculation is as follows.

$$ARP_j = O_j \sum S_i R_{ij} \quad (1)$$

$$ARP_1 = O_1 \times ((S_1 \times R_{1,1})) \quad (2)$$

ARP_1=432

Based on the ARP calculation, a Pareto diagram is made to see the priority risk agents that will be given mitigation actions first. Determination of priority risk agents is done using the Pareto principle. This principle states that in many cases, about 80% of the effects are caused by 20% of the causes. [12]. Where the risk that has a large impact is caused by a small number of risk-causing agents. Therefore, it is hoped that by mitigating the risk-causing agents that cause small risks, some of the impacts can be controlled.

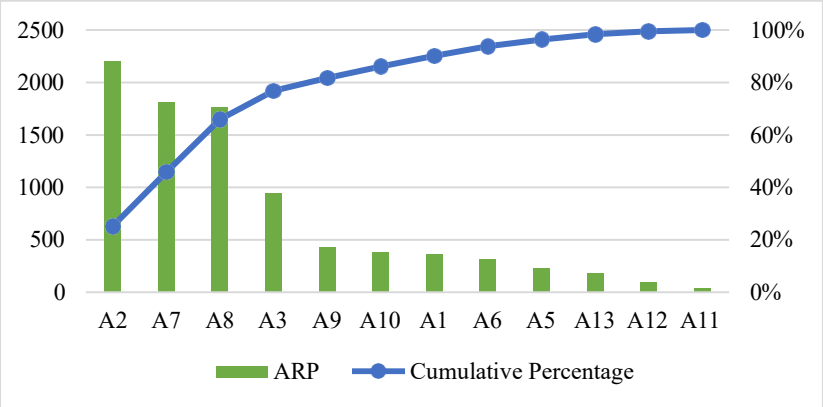

Figure 1. Diagram Pareto Aggregate Risk Potential

Based on the Pareto diagram above, it can be seen that there are 4 risk agents that have an influence of 76.82% on the risk incident. Determination of priority risk agents is carried out using the Pareto principle, which states that most impacts are caused by a small number of causes [12].

3.4. House of Risk II

House of Risk II is a stage of developing risk mitigation actions that are considered effective against priority risk agents. Risk mitigation actions are carried out to overcome or reduce the chances of the emergence or occurrence of 4 risk agents. The following are adaptive risk mitigation actions as seen in Table 3.1.

Table 1. Risk Mitigation Actions

Code	Risk Agent	Risk Mitigation Actions	Code*
A_2	Disturbances in the transportation of wet tea leaves	Conduct analysis and evaluation of employee performance	PA_1
		Create a schedule for picking up wet tea leaves	PA_2
A_6	Workers lack discipline in processing	Increase supervision of the foreman in charge at each station	PA_3
A_7	The machine is damaged	Conduct quality control by separating raw materials from hard materials.	PA_4
		Perform routine machine maintenance	PA_5
		Limit the engine load to maximum capacity	PA_6
A_8	Employees are not careful	Raise awareness to work diligently	PA_7

After designing risk mitigation actions, the next step is to assess the correlation between risk mitigation actions and risk agents by giving a score of 0, 1, 3, 9. After that, it is continued by assessing the level of difficulty in implementing risk mitigation actions. The assessment of the level of difficulty uses a score of 3, 4, 5, which respectively indicate easy to implement, slightly difficult to implement, and difficult to implement [8].

Next, the Total Effectiveness (TEk) is calculated to determine the effectiveness value of risk mitigation measures using the equation:

$$TE_k = \sum ARP_j E_{jk} \quad (3)$$

Then a comparative calculation of Total Effectiveness (TEk) with the level of difficulty or Degree of Difficulty (Dk) is carried out using the equation:

$$\text{ETD k}=\frac{\text{TEk}}{\text{Dk}} \quad (4)$$

The House of Risk II Matrix shows that the mitigation action with the highest value is the action to conduct analysis and evaluation of employee performance (PA1), with a value of 9740.25 and the lowest mitigation action value is limiting the machine load to maximum capacity (PA5) with a value of 1768.

Table 2. Risk Mitigation Action Ranking Results

Risk Mitigation Actions	Code	*Rank*
Conducting analysis and evaluation of employee performance	PA_1	1
Increasing supervision of the foreman in charge at each station	PA_3	2
Conducting quality control by separating raw materials from hard materials	PA_4	3
Creating a schedule for picking wet tea leaves	PA_2	4
Conducting routine machine maintenance	PA_5	5
Increasing awareness to work carefully	PA_7	6
Limiting machine loads to maximum capacity	PA_6	7

Mitigation actions to conduct performance analysis and evaluation can help identify employee performance that affects the delay in the arrival of raw materials, so that necessary actions can be taken to overcome problems that affect production delays. Employee performance evaluation can be done through performance assessments using Key Performance Indicators (KPIs), where companies can identify what performance needs improvement and design training or incentive programs to improve performance. Actions to improve supervision of the foreman in charge at each station because some production processes are not carried out according to the established work instructions. Some workers are less disciplined in doing their jobs, such as not being on time in moving processed tea leaves from one machine to another. The foreman at each station must increase supervision to ensure that workers work with discipline and comply with the work instructions that have been made by the company to prevent delays in processing, maintain the quality of tea powder, and prevent machine damage [10].

Furthermore, the action is to schedule the pickup of wet tea leaves to prevent delays in wet tea leaves arriving at the factory. Regular and disciplined scheduling of wet tea leaf pickups will help ensure that the supply of raw materials reaches the factory on time. So that the risk of delays in the processing process due to the late arrival of wet tea leaves can be prevented. Mitigation actions to carry out quality control by separating raw materials from hard materials are carried out because many old tea leaves along with their stems and stems as well as wild plants are found in Whitering Through (WT) which can cause disruption to production machines, especially OTR, PCR, and RV machines [11].

Maintaining the quality of raw materials can reduce the risk of machine damage which causes delays in processing. Routine maintenance actions can help prevent machine damage. By carrying out preventive maintenance regularly, companies can extend the life of the machine and avoid disruptions during the production process. Increasing awareness of the importance of working diligently will produce good quality tea leaves which are very important for the production process. Increasing awareness can be done through a personal approach, socialization, and increasing incentives for units that show improved performance. Limiting the machine load according to maximum capacity to ensure that the production machine operates according to the maximum capacity that has been determined can prevent overloading which can cause machine damage. Damaged machines have an impact on production delays due to unexpected machine repairs, which can have an impact on the smooth running of the production process. The lean service approach through value stream mapping can also be used to identify potential waste in certification and production processes [16].

The mitigation action of evaluating employee performance achieved the highest effectiveness ranking due to its direct influence on multiple risk agents, particularly those related to delays and discipline. This action addresses the root causes such as lack of coordination, inattentiveness, and inconsistent work practices. By

identifying performance gaps through Key Performance Indicators (KPIs), companies can take corrective actions, including training or incentive restructuring, to ensure more reliable operations and reduced downtime. Understanding the behavior in the adoption of operational practices, as shown in the study of halal adoption in the food industry, is also important in designing mitigation strategies [14].

Similar studies, such as those by Ratnasari et al. [6] and Marchello et al. [3], also found that human-related factors, including employee discipline and supervision, are often the most significant contributors to operational risks in manufacturing supply chains. These findings support the conclusion that mitigation strategies targeting human performance can achieve high effectiveness because they affect multiple points in the supply chain simultaneously. Evaluation of employee behavior can also consider psychological approaches such as the Theory of Planned Behavior (TPB), which has been used in the context of eco-friendly and halal food [13].

4. Conclusion

This study has successfully identified the risk factors in the orthodox Halal Black Tea production supply chain at Tobasari Tea Unit of PTPN IV using the Supply Chain Operation Reference (SCOR) and House of Risk (HOR) approaches. The results of the analysis show that there are 21 risk events with 4 priority risk agents, where the Aggregate Risk Potential (ARP) value reaches 76.82%. The main risks found in this study include delays in raw material processing due to late arrival of wet tea leaves, disruptions to production machines that hinder operational processes, and lack of worker discipline in carrying out production procedures.

Based on the results of the House of Risk II analysis, several recommended risk mitigation strategies include analysis and evaluation of employee performance to improve work efficiency, increased supervision of foremen at each work station to ensure smooth production, and control of raw material quality by separating hard materials from the main materials to avoid machine damage. In addition, scheduling the transportation of wet tea leaves in a disciplined manner is also an important mitigation step to prevent delays in the production process. Routine machine maintenance is also recommended to prevent technical disruptions that can hinder production. The implementation of this mitigation strategy is expected to significantly reduce risk and increase the efficiency and reliability of the production process at Tobasari Tea Unit of PTPN IV.

Although this study has provided valuable insights into risk analysis in the tea production supply chain, there are several aspects that can be further explored in future research. First, the development of a risk prediction model using machine learning or artificial intelligence (AI) technology can help companies anticipate risks before they occur. Second, data-based supply chain schedule and logistics optimization can be studied further to improve the efficiency of raw material and final product distribution, thereby minimizing production delays. In addition, evaluating the impact of implementing technologies such as the Internet of Things (IoT) in the production system can be the focus of further research to improve machine reliability and reduce operational disruptions.

The social and organizational aspects of risk management are also interesting areas for further research. Factors such as organizational culture, work motivation, and leadership play an important role in managing operational risk in the manufacturing sector, especially in the tea industry. Future research can also conduct comparative studies with other agribusiness industries that have complex supply chains to see the similarities and differences in risk management and the most effective mitigation strategies. With further development, it is hoped that this research can provide a broader contribution to increasing the efficiency and resilience of the supply chain in the tea industry and other manufacturing sectors.

The findings of this study extend beyond the Tobasari Tea Unit of PTPN IV and offer broader practical implications for the national tea industry in proactively managing operational risks. The systematic approach utilizing SCOR and HOR can be applied to other agribusiness sectors with similar supply chain characteristics. Furthermore, this research may serve as a reference for strategic corporate policymaking aimed at enhancing efficiency and resilience in supply chain operations.

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References

[1] T. Ding and Z. Huang, "Uncovering the research hotspots in supply chain risk management from 2004 to 2023: A bibliometric analysis," Sustainability, vol. 16, no. 12, p. 5261, 2024.
[2] S. Kurniawan et al., "Risk and supply chain mitigation analysis using House of Risk method and Analytical Network Process: A case study on palm oil company," The Winners, vol. 22, no. 2, pp. 123–136, 2021.
[3] D. Marchello et al., "Analisa mitigasi risiko manajemen rantai pasokan menggunakan pendekatan House of Risk pada perusahaan manufaktur tepung agar-agar instan," J. Ilm. Tek. Ind., vol. 11, no. 2, 2023.
[4] A. Lokobal et al., "Manajemen risiko pada perusahaan jasa pelaksana konstruksi di Provinsi Papus (studi kasus di Kabupaten Sarmi)," J. Ilm. Media Eng., vol. 4, no. 2, 2014.
[5] M. Basorudin et al., "Kajian pesebaran komoditas teh: Pengembangan kawasan perkebunan teh di Provinsi Jawa Barat tahun 2015," J. Sos. Ekon. Pertan., vol. 15, no. 3, 2019.
[6] S. Ratnasari et al., "Supply chain risk management in newspaper company: House of Risk approach," AIP Conf. Proc., vol. 1931, no. 1, 2018, doi: 10.1063/1.5024075.
[7] I. N. Pujawan and L. H. Geraldin, "House of Risk: A model for proactive supply chain risk management," Bus. Process Manag. J., vol. 15, no. 6, 2006, doi: 10.1108/14637150911003801.
[8] S. Sinulingga, *Metode Penelitian*, 3rd ed. Medan: USU Press, 2016.
[9] E. W. Abryandoko and Mushthofa, "Strategi mitigasi risiko supply chain dengan metode House of Risk," Rekayasa Sipil, vol. 14, no. 1, 2020.
[10] A. Shahin, "Integration of FMEA and the Kano model," Int. J. Qual. Reliab. Manag., vol. 21, no. 7, 2004, doi: 10.1108/02656710410549082.
[11] Sunarto and H. S. W. N., *Buku Saku Analisis Pareto*, Magetan: Poltekkes Kemenkes Surabaya, 2020.
[12] A. Shalihin, T. Alda, C. E. Revadi, and F. R. P. Nasution, "Consumer intentions to purchase eco-friendly halal food in Medan, Indonesia: An approach using the theory of planned behavior," Eng. Proc., vol. 84, p. 83, 2025, doi: 10.3390/engproc2025084083.
[13] A. Shalihin, H. Nasution, J. Hidayati, and I. Vanany, "Halal practice adoption behaviour in the food industry: A focus group discussion," Evol. Stud. Imaginative Cult., vol. 8, pp. 450–460, 2024.
[14] A. Shalihin, H. Nasution, I. Vanany, and J. Hidayati, "A review of halal food supply chain practices research," in *Proc. 13th Annu. Int. Conf. Ind. Eng. Oper. Manag.*, Manila, Philippines, Mar. 6–9, 2023, pp. 2283–2291.
[15] A. Shalihin and J. Hidayati, "Approach lean service on halal certification service system using cost integrated value stream mapping," IOP Conf. Ser.: Mater. Sci. Eng., vol. 725, p. 012065, 2020.
[16] A. Shalihin, H. Nasution, I. Vanany, and J. Hidayati, "Exploring the factors influencing halal practice adoption in the food supply chain: A qualitative study," Kurd. Stud., vol. 12, no. 1, pp. 1338–1351, Jan. 2024.