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Analysis of Supply Chain Risk Control in Aceh Nut Work Using the House of Risk Method Approach (Case Study: Nutmeg Oil Industry in South Aceh Regency)

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ABSTRACT

South Aceh nutmeg oil plays an important role in the trade of essential oils from Indonesia. 70-80% of Indonesia's nutmeg oil trade comes from South Aceh. However, on the other hand, there is a disruption in price stability in the production of South Aceh nutmeg oil which is influenced by the quality standards of nutmeg oil. The purpose of this study is to identify potential risks that arise in the supply chain, find risk agents as the cause of the risk and control the risk by designing risk mitigation and its formulation in the structure of the nutmeg oil supply chain in South Aceh. The technique used in this study is the House Of Risk (HOR) method. The study has obtained 23 risk events and 17 priority risk agents covering Source, Make, Distribution and Costumer (Return) activities. Then from the risk agents obtained, 11 priority mitigation actions were also obtained as a control of the performance of the nutmeg oil supply chain that can be applied in an effort to reduce the occurrence of supply chain risks so that the industry is able to produce optimally and is able to improve the quality of nutmeg oil which of course has a positive impact on the selling value.

I. Introduction

Nutmeg (Myristica fragrans houtt) is a fruit plant with a tall tree habitus native to Indonesia, because this plant comes from Banda and Maluku. The nutmeg plant has the advantage that almost all parts of the stem and fruit can be used, starting from the bark and leaves, mace (a red object that covers the seed skin), nutmeg seeds and nutmeg fruit flesh.

The main products of nutmeg plants are seeds and mace which are used as spices. Nutmeg seeds contain 7-14% essential oil. Oil from the distillation of young nutmeg seeds can be used as raw materials for the pharmaceutical industry, making soap, perfume and cosmetics domestically (Dahlia, 2016).

Nutmeg production centers in Indonesia are located in 5 (five) provinces, namely Aceh, North Maluku, North Sulawesi, Maluku and West Papua. The five provinces provide a cumulative contribution of 86.71%. Aceh ranks first with a contribution of 25.46% per year. In 2014, the largest nutmeg production came from South Aceh Regency with a production of 7.56 thousand tons or 91.83% of the total nutmeg production in Aceh Province (Ministry of Agriculture, 2016).

Although nutmeg is a superior commodity, people's nutmeg farming still has many shortcomings caused by: (a) some plants are old/damaged and unproductive; (b) not using superior seeds; (c) not implementing cultivation technology according to recommendations; and (d) pest and

disease disturbances. Meanwhile, low nutmeg productivity also results in less than optimal nutmeg production National nutmeg cultivation, which is almost entirely managed by People's Plantations, still has not implemented appropriate cultivation technology, low yield quality because harvesting and processing are still traditional and product cleanliness/health is not guaranteed [1] [2].

Supply Chain is an integrated system that coordinates the entire process in an organization/company in preparing and delivering products/services to consumers. This process includes planning (plan), input sources for the process (source, for example delivery of raw materials from suppliers), the process of transforming inputs into outputs (make), transportation, distribution, warehousing (deliver), information systems, and payment for products/services, until the product/service is consumed by consumers, as well as product/service return services (return) [3]. The supply chain emphasizes more on all activities in meeting consumer needs which include the flow and transformation of goods from raw materials to end consumers and accompanied by the flow of information and money. Technically, supply chain management for agricultural products is more complex than non-agricultural products [4], due to the nature of agricultural products which are perishable (perisbale), seasonal (seasonal), bulky, scattered production locations with varying quality qualifications [3][5]. In this case, it can be said that agricultural product supply chain management has more risks compared to non-agricultural ones.

Risk is all events that may arise in the supply chain process that result in losses to the industry. According to Sastra [6] risk is an unexpected effect that arises from the goals to be achieved both internally and externally. Therefore, risk management is needed to avoid the risks that arise.

There are several studies that discuss supply chain risks in agricultural products, especially nutmeg in South Aceh, including; [7] on the nutmeg oil supply chain and [7] in analyzing the nutmeg supply chain. Technically, in the industry, industry players are required to be able to manage the risks that occur in the industrial supply chain, so that the impact of the risks that occur can be avoided or minimized. One technique that can be used to manage and avoid these risks is the House Of Risk (HOR) method. Several studies have applied this technique, including [3] in mapping proactive strategies to mitigate risks that arise and create a robust supply chain at the Petrokimia Gresik factory. Almost the same research was also conducted [8], namely the House of Risk (HOR) Model for risk mitigation in the Gempol - Pasuruan toll road construction project who used this method to design mitigation strategies in the patchouli oil industry in Aceh Jaya district.

Based on field observations, it is known that the nutmeg supply chain in South Aceh includes essential oils (nutmeg oil), spices and processed food and beverage products. This study focuses on risk analysis and mitigation in the nutmeg oil supply chain. Then the problem statement of the study can be compiled, namely what risk events may arise in the nutmeg oil supply chain including source to customer activities and what mitigation strategies are needed. The purpose of this study is to identify risk events that occur in the nutmeg oil supply chain and design the mitigation strategies needed for the nutmeg oil supply chain in South Aceh.

II. Method

Data collection technique

Data collection techniques in this study were carried out by means of observation, interviews, and discussions. The data collection process was carried out intentionally (purposive) and conducted through direct interviews. Several parties who became respondents in this study included nutmeg farmers who were active in processing nutmeg every day, starting from sorting nutmeg after harvest to the handling process to the final results that could be sold to the market. The second source from nutmeg entrepreneurs who produced processed nutmeg oil, obtained information on selecting nutmeg

based on quality grade, the amount of raw materials needed, the amount of processed production and the selling price.

Data Analysis Methods

In conducting supply chain risk analysis, the House of Risk (HOR) model will be used, which aims to identify, analyze, measure and mitigate potential risks. The implementation of HOR consists of two stages, namely:

A. HOR phase 1; used to identify risk events and risk agents that may occur (potential). The result of HOR phase 1 is the grouping of risk agents into priority risk agents according to the Aggregate Risk Potential (ARP) value. HOR phase 1 is the initial stage that aims to identify risk events and the risk agents that cause them. The following are the stages in the HOR phase 1 process:

1) Identify the company's business processes/supply chain activities based on the business processes being run. This aims to find out where the risks can arise.
2) Identify risk events (Ei) for each business process that has been identified in the initial stage. This risk is all events that may arise in the supply chain process that result in losses to the company.
3) Measurement of the level of impact of a risk event (Si) on the company's business processes. The value scale used is a value of 2 indicating that the impact that arises has a small influence on the sustainability of the supply chain, a value of 3 indicating that the impact that arises has a moderate category influence on the sustainability of the supply chain, a value of 4 indicating that the impact that arises has a serious impact on the sustainability of the supply chain.
4) Identification of risk-causing agents (Aj). This describes what factors can cause the occurrence of risk events that have been identified in the previous stage.
5) Measurement of the probability value of the occurrence of a risk agent. This occurrence states the level of probability of the frequency of occurrence of a risk agent resulting in the occurrence of one or more risk events that can cause disruption to the business process with a certain level of impact. This probability level uses a scale, namely; scale 1 indicates the possibility of the risk agent occurring only once a year, scale 2 indicates the possibility of the risk agent appearing only once in several months of operation and scale 3 indicates the risk agent occurring once in several weeks of operation.
6) Measurement of the correlation value between a risk event and a risk-causing agent. If a risk agent causes a risk, then there is a correlation. The correlation value (Rij) consists of 0, 1, 3, 9. Where 0 (zero) indicates no correlation, 1 (one) describes a small correlation, 3 (three) describes a moderate correlation and 9 (nine) describes a high correlation.
7) Calculation of the risk priority index value/ Aggregate Risk Potential (ARP). This index value will be used as a consideration to determine the priority of risk handling which will later become input in HOR phase 2. The calculation of the ARP value uses the following formula;

$ARP_j = O_j \Sigma Sir Rij$

Table 1. Overview of Phase I HOR Calculation

Supply Chain Activities	Risk Events	Risk Agent (Ai)				Impact Level
		A1	A2	A3	A4	
Supply	E1	R11	R12	R13		S1
Production	E2	R21	R22			S2
Distribution	E3	R31				S3
Consumer	E4	R41				S4
Probability Level		O1	O2	O3	O4	
Risk Priority Index (ARP)		ARP 1	ARP 2	ARP 3	ARP 4	
Risk Agent Rating						

A. HOR phase 2; used for designing mitigation strategies carried out to handle priority category risk agents. The results of HOR phase 1 will be used as input for HOR phase 2. HOR phase 2 is the design of mitigation strategies to handle (risk treatment) identified risk agents and some at priority risk levels. The implementation of HOR phase 2 includes several stages of work, namely;
   1) Selecting risk agents from the highest to the lowest ARP value using Pareto analysis. Risk agents that are included in the high priority category will be input into HOR phase 2. Determination of the priority risk agent category is done using Pareto's law or known as the 80:20 law. The application of Pareto's law to risk is that 80% of company losses are caused by 20% of crucial risks. By focusing on 20% of crucial risks, the impact of 80% of the company's risks can be overcome.
   2) Identify relevant mitigation actions (MIA) against emerging risk agents. Risk treatment can apply to one or more risk agents.
   3) Measurement of correlation between a risk agent and risk management. The correlation relationship will be a consideration in determining the degree of effectiveness in reducing the emergence of risk agents.
   4) Calculate the total effectiveness (TEk) for each risk agent using the following formula;
      TEk =ΣARP_j E_{jk}
   5) Measuring the level of difficulty in implementing mitigation actions (Dk) in an effort to reduce the emergence of risk agents.
   6) Calculate the total effectiveness of implementing mitigation actions/effectiveness to difficulty of ratio (ETDk) using the following formula;
      ETDk = TEk / Dk
   7) Prioritize from the highest to the lowest ETD value. The highest priority value is given to the mitigation action with the highest ETD value.

Table 2. Overview of Phase I HOR calculations

Risk Agent	Mitigation Action				Risk Priority Index (ARP)
	PA1	PA2	PA3	PA4	
A1					ARP1
A2					ARP2
A3					ARP3
A4					ARP4
Total Effectiveness (TEk)	TE1	TE2	TE3	TE4	
Difficulty Level of Implementing Mitigation Actions	D1	D2	D3	D4	
Effectiveness of Implementation of Mitigation Actions	ETD1	ETD2	ETD3	ETD4	
Priority Ranking	R1	R2	R3	R4	

III. Results and Discussion

Supply chain risk analysis was conducted on the ABC nutmeg oil industry, where based on statistical data this company is one of 5 companies that have the highest nutmeg oil production from around 80 companies spread across the South Aceh district. The work risks in the nutmeg supply chain to become nutmeg oil were analyzed for risk events that have occurred over the past year, as well as risks that are likely to arise in the future. This analysis includes the stages of identifying risk events, measuring risk events that occur and taking risk mitigation actions.

In a long-running supply chain system, there are generally several links and they play an important role in the continuity of the supply flow of raw materials to become products. Therefore, before identifying risk events in chain activities, it is advisable to map the components of the nutmeg

oil supply chain system activity network. The following are the components of the nutmeg oil supply chain system activity mapping network.

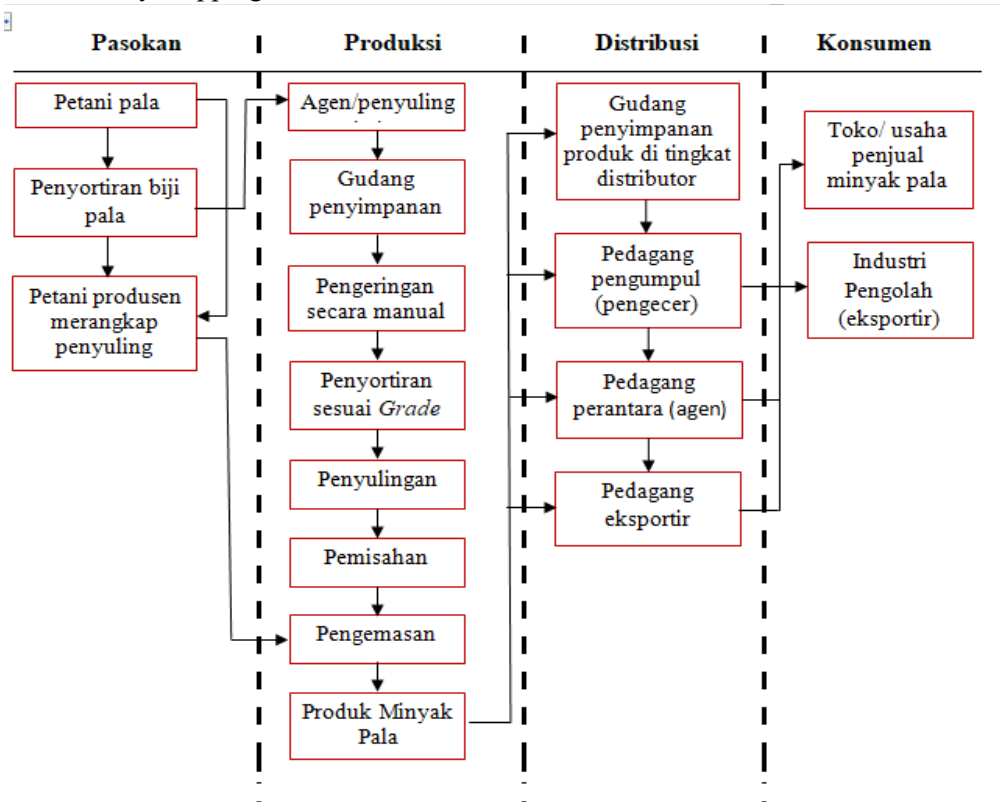

Fig 1. Components of nutmeg oil supply chain activities

The supply chain flow in the nutmeg oil refining industry can be started by collecting nutmeg seeds by nutmeg farmers. After the harvest, nutmeg seeds as the main raw material for making nutmeg oil are sorted according to the agreed specifications to obtain high-quality nutmeg oil. Furthermore, if the raw materials are received, they will be stored in the production warehouse for further refining. Raw materials are produced with several stages of processing before reaching the refining process to produce nutmeg oil. The refined nutmeg oil is packaged and the final product is inspected. If the product produced meets the standards and is of the desired quality, the product is stored in the storage warehouse and if there is a request from the distributor, the product will be sent to the next party (shop and processing industry), the distributor will send it to the retailer level and forwarded to the customer level.

A. Hor phase i

In Phase I, after mapping the supply chain activity components, it is divided into 4 processes, namely source, make, distribution and costumer. After determining the components in the supply chain, it is continued by identifying each risk event that has the potential to arise in each process. Risk events are coded with the letter Ei (where i is the number of risk events) which aims to facilitate further reading.

From the analysis results, 23 risk events can be identified that have the potential to cause disruptions in the supply chain process, where 5 risk events occur at the source, 9 risk events at the manufacturer, 7 risk events at the distributor and 2 risk events at the customer, which can be seen in Table 3. Furthermore, an assessment of the level of impact of the disruption caused by the risk event is carried out on a scale of 1-4.

Of the 23 risk events, there are 4 risk events that have an impact level value with a scale of 1, indicating that the impact caused has a small influence on the sustainability of supply chain activities, 10 risk events that have a scale value of 2, indicating that the risk event has a moderate impact on

the sustainability of supply chain activities and there are 4 risk events that have an impact level value with a scale of 3, this indicates that the risk event has a serious impact on the sustainability of the supply chain and 5 risk events have an impact level value with a scale of 4, this indicates that the risk event has a serious impact on the sustainability of the supply chain.

After determining the risk event, the risk agent that causes the risk event can be identified. Measuring the level of occurrence of a risk agent states the level of probability of the frequency of occurrence of a risk agent resulting in the occurrence of one or more risk events that can cause disruption to the production process with a certain level of impact. Determination of this risk agent is carried out using a scale assessment of 1-4 to measure the level of probability of the occurrence of the risk agent, where scale 1 describes the occurrence of risk rarely or almost never occurs, scale 2 describes quite often or occurs several times, scale 3 describes the occurrence of risk often, scale 4 describes the occurrence of risk that occurs very often.

The results of the risk agent identification obtained 37 risk agents that have the potential to trigger the emergence of risk events in the industrial supply chain process. Based on the results of the assessment of the risk agent emergence scale, scale 1 was obtained as many as 6 risk agents, scale 2 as many as 16 risk agents, scale 3 as many as 10 risk agents and scale 4 as many as 5 risk agents. The measurement results for the risk agent emergence scale can be seen in Table 4.

Next, measurements are taken to find the relationship or correlation between a risk event and the risk-causing agent. One risk agent can cause several risk events and vice versa. The results of this measurement are carried out on a scale of 0, 1, 3 and 9 where 0 explains that there is no relationship between the risk agent and the risk event and 1 explains a low relationship, 3 explains a moderate relationship and 9 explains a high relationship. The results of this measurement can be seen in Table 4.

Next, the Aggregate Risk Potential (ARP) calculation can be carried out on each risk agent. The calculation of the ARP value aims to number or rank priorities for each risk agent. The risk agents will be sorted based on the highest to lowest ARP value. The final result of the HOR Phase I calculation process is the identification of risk agent priorities. The following ARP calculation uses the following formula;

$$ARP_j = O_j \sum_i S_i R_{ij}$$

Here is an example of ARP calculation$_{29}$as the highest ARP value, for other ARP calculation results can be seen in Table 4.

$$ARP_{29} = 4 \times \sum[9 \times 4 + 3 \times 4]$$
$$ARP_{29} = 4 \times \sum[36 + 12]$$
$$ARP_{29} = 4 \times \sum[48]$$
$$ARP29 = 192$$

Table 3. Measurement of the level of impact of risk events

No.	Risk	Process	Code (Ei)	Impact
1	Procurement/availability of raw materials (continuity of supply).	*Source*	E1	1
2	The supply sorting system is still manual.	*Source*	E3	1
3	Very high fluctuations in raw material prices.	*Source*	E 5	1
4	Price fluctuations become very high.	*Distribution*	E18	1
5	Lack of technology for drying raw materials.	*Make*	E7	2
6	Low oil yield.	*Make*	E12	2
7	Dirty/not clear oil.	*Make*	E13	2
8	The oil is not optimally distilled.	*Make*	E14	2

No.	Risk	Process	Code (Ei)	Impact
9	The information system between managers and traders/markets is still weak.	*Distribution*	E16	2
10	The existence of market monopoly in its trading system.	*Distribution*	E17	2
11	Difficulty in accessing modern markets and export markets.	*Distribution*	E19	2
12	Delay in delivery.	*Distribution*	E20	2
13	Dirty/not clear oil.	*Distribution*	E13	2
14	Product return risk.	*Customer*	E22	2
15	The number of products does not match the request.	*Customer*	E23	2
16	Supply of raw materials whose quality is not yet guaranteed.	*Source*	E2	3
17	The influence of climate/weather on the drying process.	*Make*	E6	3
18	Risk of equipment damage during the refining process.	*Make*	E9	3
19	Risk of decreased production results.	*Make*	E11	3
20	Damage to raw materials during storage.	*Source*	E4	4
21	Use of less effective refining technology.	*Make*	E8	4
22	The packing process is less effective and manual.	*Distribution*	E15	4
23	Product damage during shipping process.	*Distribution*	E21	4

Table 4. Measurement of the relationship between risk events and risk agents

Aktivitas Rantai Pasok	Kejadian Risiko	Agen Risiko																																				Tingkat Dampak
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	
Source	E1	3	3																																				1
	E2			1																																			3
	E3					9																																	1
	E4						3	3		9	3																													4
	E5										3	3																											1
Make	E6												3	1	9	3																							3
	E7														9	3																							2
	E8																					3	3	3															4
	E9																					3		3															3
	E10																									9	9												4
	E11											3					3		3				3																3
	E12				3																3																		2
	E13																	9		3	9			9	9														2
	E14									3										3			3																2
Distribution	E15																											3	3	3									4
	E16																														3		3						2
	E17																														9	9							2
	E18																															9							1
	E19																														3	3	3						2
	E20																																	1	3				2
	E21																												3	9						1			4
Customer	E22																																				3	3	2
	E23																																					1	2
Tingkat Probabilitas		2	2	2	2	4	4	3	4	2	2	3	3	2	4	3	2	2	2	2	1	1	1	1	1	3	3	3	2	4	3	2	3	2	2	3	1	2	
indeks Prioritas Risiko (ARP)		6	6	6	12	36	48	36	144	36	6	36	27	6	180	45	18	36	18	24	24	21	27	39	18	108	108	36	48	192	90	66	36	4	12	12	6	16	
Peringkat Agen Risiko		17	17	17	16	10	7	10	3	10	17	10	11	17	2	8	14	10	14	12	12	13	11	9	14	4	4	10	7	1	5	6	10	18	16	16	17	15	

B. Hor phase II

In this phase II, priority risk agents are determined using the Pareto law or known as the 80:20 law where 20% of risk agents have an 80% impact on risk events. 17 priority risk agents were obtained, namely A29, A14, A8, A25, A26, A30, A31, A6, A28, A15, A23, A5, A7, A9, A11, A17, and A27 which have an impact on risk events of 80.81%. So that for the 17 priority risk agents, planned and sustainable actions need to be taken as handling actions.

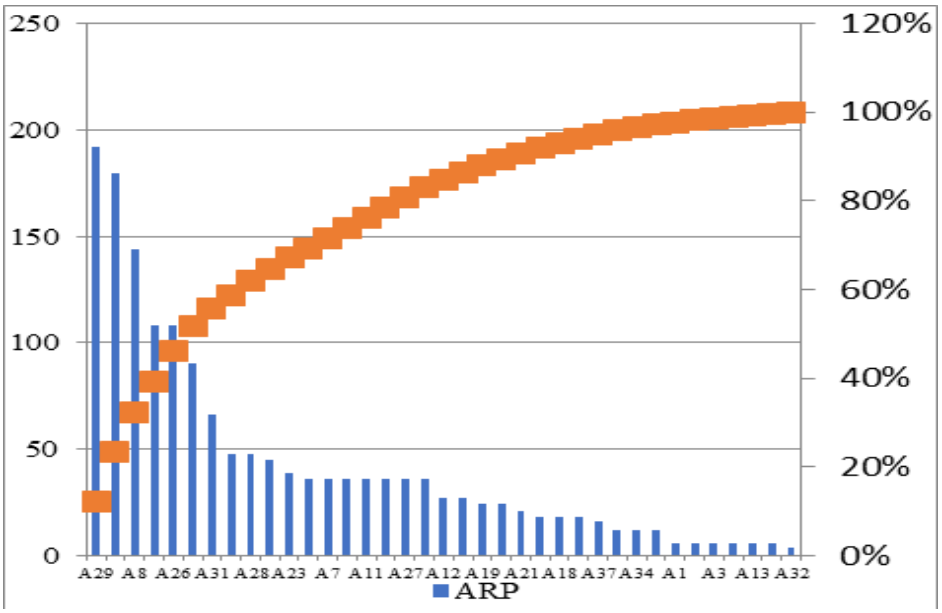

Fig 1. Hor phase II

Next, the measurement of the level of relationship between risk agents and risk mitigation actions is carried out. The value of the relationship level with a scale of 0, 1, 3, 9 which describes from no relationship to high relationship. Next, the calculation of the level of effectiveness (TEk) and Effectiveness to Difficulty Ratio (ETDk) is carried out. Furthermore, the ranking is determined by sorting the highest ETD value to the lowest. Can be seen in Table 5.

Table 5. Mitigation actions againstEffectiveness to Difficulty Ratio

No	Mitigation Action	Code (PAj)	Acting	ETDk
1	Considering forming a quality control team for raw material quality	PA4	1	797
2	Perform re-sorting before the distillation process	PA6	2	648
3	Determine special packaging that complies with SNI	PA17	3	621
4	Create work and safety steps or Standard Operating Procedures (SOP) for the production process	PA5	4	567
5	Establish cooperative relationships with testing centers or companies that provide survey/certification services.	PA16	5	486
6	Provide special drying equipment to accommodate the drying process.	PA7	6	466
7	Forming a logistics verification team	PA18	7	444

8	Conduct a survey on product packaging according to standards	PA19	8	360
9	Provide a special warehouse for storing raw materials to protect them from humid temperatures.	PA2	9	288
10	Conducting reviews and selection of quality raw materials	PA8	10	270
11	Providing a laboratory and forming an analysis team to analyze each production result	PA14	11	243
12	Establish relationships between nutmeg oil producers to exchange needed information	PA20	12	234
13	Perform maintenance and cleaning on the distillation equipment regularly	PA12	13	230
14	Carry out repairs on damaged distillation equipment according to procedures	PA13	14	176
15	Arrange the implementation of raw material supply management activities so that they are always maintained	PA9	15	162
16	Carrying out the purification process after distillation	PA10	15	162
17	Establish product quality standard criteria according to SNI	PA15	16	108
18	Conduct specific reviews of modern and export markets	PA21	17	90
19	Providing separation tool technology for nutmeg	PA1	18	81
20	Form a quality control team for the production process	PA11	19	75
21	Equip the warehouse with ventilation to maintain air circulation.	PA3	20	72

IV. Conclusion

From the results of data processing and analysis of supply chain management risk data in the nutmeg oil industry in South Aceh district, the following conclusions can be drawn;

1. Based on the analysis results, 23 risk events were obtained, of which 5 risk events occurred at the source, 9 risk events at the manufacturer, 7 risk events at the distributor and 2 risk events at the customer.
2. 37 risk agents were obtained that could cause risk events.
3. Based on the analysis using the Pareto diagram, 17 priority risk agents were obtained which had an impact of 80.81% on the potential risk events and were a priority.

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