RISK ANALYSIS IN SUPPLY CHAIN AT SMALL MEDIUM ENTERPRISE FOR CLAM AND SEAWEED (*KERULA*) CRACKERS PRODUCTS

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ABSTRACT

The large ammount of clams and seaweed has not been managed very well by local small medium enterprise (SME). Supply chain management is kind of a system that arrange the flow of material, information and money between suppliers to end customers. Kerula is blended product of Clam and Seaweed (*kerang and rumput laut*, *Kerula*). The problem is determining risk in supply chain at SME in Sumberasih Sub-district Probolinggo East Java, is not able to process the clams and seaweed into food products which is interested by the indigenous people. The purpose of this research is to identify supply chain of Kerula product in SME in Sumberasih Sub-district, and to overcome the problem of risk management and increase the added value in the supply chain of Kerula product by using data collection methods such as observation, literature study, interviews, and questionnaires involved. This research use data collection then the data is processed by using FMEA which contains three parameters, namely severity, occurrence and detection. This method provides solutions for supply chain management that integrate the elements to reduce and minimize the risks. This SME in Sumberasih Sub-district has one supply chain network which is supplier, agents, shop and customers. The result from FMEA method means that to improve the implementation of supply chain management in Sumberasih Sub-district can be done with handling the risks that occurs when the selection of raw materials, storage and so on. The maximum RPN is 448 that means difficulties in selling products. This research correspond to the previous research.

Keywords: kerula product supply chain network, FMEA, severity level, risk priority number.

1. INTRODUCTION

Agro-industry can be a strategic choice in dealing with problems and efforts to improve the economy of the community who are generally in rural areas and create employment opportunities for the surrounding community. Agro-industry is an effort to increase the efficiency of the industrial sector in order to make it a very productive activity through industry modernization process by analyzing the distribution of flow of goods from each element and to determine the occurring risk factors so that it will optimize the performance of the supply chain. Several researches have studied about meat ball beef however they have not done risk analysis in supply chain (Hsu and Chung, 1998, 2001; Tseng et al., 2000; Hsu and Yu, 1999; Huda et al., 2010; Hsu, and Sun. 2006; Ulu, 2004, 2006; Sendaroglu and Degirmencioglu. 2004; Huang et al., 2005; Yilmaz, 2005; Serdaroglu, 2006). Some other researches have studied about carrageenan seaweed however they have not investigated risk analysis in supply chain (S.Y. Hsu and Chung. 2001; Hasret Ulu, 2006). The objective of this research is to determine risk and improve performance in supply chain at SME in Sumberasih Sub- district Probolinggo East Java. The results obtained from the identification will be used to manage the risk management that occurs in shell and seaweed product industry. So that the supply chain can run effectively and efficiently and optimize the income of fisherman community.

Kerula is a combination of clam and seaweed. The importance of knowing the supply chain of kerula products is to know the survival of the kerula business. Clam have been studied by Nurmianto and Pamungkas (2018). Seaweed has been studied by Wessiani, Nurmianto, and Armono (2013) in Sumberasih Subdistrict which is a subdistrict in the Probolinggo Regency region which has great potential in developing business in seaweed aquaculture and processing of captured clam. In these areas, many fishermen catches include clam, shrimp, mangrove crabs, and grouper fish, snapper. Clam and seaweed processing business has not been developed by the fishermen in that area even though its natural potential is quite supportive. Usually, the fishermen only sell smallsized captured clams so that they have more economic value. So far no one has the idea to make a combination of food from clam and seaweed. In this research, a combination of those two materials, clam and seaweed, was made and named **kerula**, as shown below.

Figure 1.1 Equipment and material for kerula

Figure 1.2 *Briefing* participant of food processing kerula

Figure 1.3 Weighing of kerula

Figure 1.4 Kerula processing

Figure 1.5 Seaweed filtering

Figure 1.6 Finished products, kerula cracker & meatball

Figure 1. Kerula Making Process

Previous studies on clam processing by Nurmianto and Pamungkas (2018) and seaweed were carried out by Wessiani et al. (2013). In Sumberasih sub-district Probolinggo 70% of the productive age population work as fishermen, fish farmers and rice farmers. Knowledge of shell processing is obtained from field experience.

Communities in the sub-district still need further coaching to increase the knowledge, capabilities and technology transfer of shell processing. The clam caught by Sumberasih sub-district fishermen is quite large, but is underutilized. Clam can be used as a food source. There is still available fishing land that has not been utilized by the community, such as water intake channels or irrigation in the area of the pond or river estuary. Collection of processing clams is not a problem, because these processing products can be marketed in the Sumberasih sub-district or at Sea food markets and restaurants in Surabaya.

Clam processing business can be done by anyone, no exception in certain levels of education. Considering that most community members are able to process clam and work together with various parties and related institutions, besides optimizing the utilization of clams from Sumberasih community, which is very high, it is also necessary to get attention to be optimized as the main material for clam smoking. In addition to smoking, clam waste can also be used for Nurmianto and Pamungkas 2018 handicraft products; Nurmianto and Priyo (2010)

Clam are abundant in the tropics, especially around the coastal areas of Probolinggo Regency. In Probolinggo since ancient times, clam have been found almost on the beaches in Probolinggo District. So far, the utilization of clam waste is limited to complementing children's toys. So that the price of clam becomes very cheap, due to the community not yet optimal in utilizing clams.

Kec. Sumberasih, Probolinggo District has a large potential for producing clams. During this time, clam produced by fishing communities are still sold as raw materials and have not been processed into finished products.

2. LITERATURE REVIEW

Seaweed supply chain has been studied by several researchers. Gunasekaran, Patel, and Mcgaughey (2004) Supply chain management (SCM) has become a major component of competitive strategies to increase organizational productivity and profitability. The literature on SCM relating to strategy and effective technology in managing supply chain is quite extensive. In recent years, performance measurements and organizational metrics have received much attention from researchers and practitioners. The role of performance measurement and metrics in the success of an organization cannot be overstated because it influences strategic, tactical, and operational planning Mulyati and Geldermann (2016) have studied the seaweed supply chain in Indonesia, especially with carrageenan and jelly products, have risks that are appear within participating companies and on external networks. Uncertainty in results, quality, price, and infrastructure in one part of the supply chain can affect the entire chain**.** To ensure a sustainable seaweed industry, proper supply chain risk management (SCRM) is needed. There are four important steps in SCRM: identifying seaweed supply chains, identifying and classifying risks, assessing risks, and mitigating risks. To identify supply chain seaweed, Mulyati and Geldermann (2016) have conducted field research, conducted in-depth interviews, and literature studies. Field surveys were carried out in the provinces of South Sulawesi, West Java, East Java, Banten and West Nusa Tenggara.

Seaweed supply chains are modelled by Umberto software to get a better understanding of the flow of material and energy between key members.

To identify and classify risks, we start with the risks mentioned in the existing work literature, and then apply the Delphi method to analyse potential sources of risk, their causes, and their impact. To assess risk, we use a semi-quantitative approach through face-to-face interviews to produce risk maps that show the likelihood, and adverse impacts. After that, the intensity of risk is categorized based on the value of the response and classified into five categories: neglected, marginal, critical, most critical, and disaster risk. Mitigation strategies are considered sustainability (environmental, economic, and social) and risk criteria. Multi-criteria decision analysis is used to evaluate the strategy.

Buschmann et al. (2017) and Engle et al. (2018) have studied the use of seaweed that has a long history, as well as the cultivation of selected and relatively small groups of species. This review presents several aspects of seaweed production, such as updates on the volume of seaweed produced globally through extraction from natural layers and aquaculture. Buschmann et al. (2017) have discussed uses, production trends, and economic analysis. We also focus on what is seen as great potential for the growth of industrial-scale seaweed volume providing sufficient and sustainable biomass to be processed into many products to benefit humanity. Most important, Engle et al. (2018) has provided an outline for future needs with the anticipation that phycologists around the world will face challenges, so that the potential obtained from seaweed biomass becomes a reality.

2.1 Failure Mode and Effect Analysis (FMEA)

FMEA Method from Stamatis (1995), Shahin (2004), Pujawan (2009) Pujawan and Geraldin (2009) show that there are three parameters, namely severity (the degree of risk event severity), occurrence (possible frequency of occurrence of risk agent), detection (relationship or correlation between risk events and risk agents) can used to calculate risk priority number (RPN).

1) Severity Level (*Severity*)

Severity is an assessment of the seriousness of the effects caused, which means that every failure that arises will be assessed how much the level of seriousness. There is a relationship between effects and severity. For example, if the effect that occurs is a critical effect, the severity value will also be high. Vice versa, if the effects that occur are not from critical effects, then the severity value will be low.

Table 1. Severity Level Wang *et al* (2009)

Effect	*Rating*	*Severity Effect*
Hazardous without warning	10	The severity level is very high when the failure mode affects the safety system with a warning
Hazardous with warning	9	The severity level is very high when the failure mode affects the safety system with a warning
Very High	8	The system that cannot operate, failure causes damage without endanger safety
High	7	The system cannot operate with equipment damage
Moderate	6	The system cannot operate with minor damage (Minor)
Low	5	The system cannot operate without failure
Very Low	4	The system can operate when performance has decreased significantly
Minor	3	The system can operate with some decreased performance
Very Minor	2	The system can operate with little disruption
None	1	No effect

2) Occurrence Level (*Occurrence*)

Occurrence is a possibility that the cause will occur and produce a form of product failure during the period of use. Occurrence is a rating value that is adjusted to the frequency that can be estimated or the cumulative number of failures that occur.

3) Detection Method (*Detection*)

The detection value associated with the current control. Detection is a measurement of the ability to control or control failures that occur. The value of detection can also determine the relationship or correlation between risk identification (risk event) and the source of risk (risk agent).

Table 2. Occurrence Level Wang *et al.* (2009)

Probability of occurance	*Rating*	*Failure probability*
Very High: Failures in which unavoidable	10	> 1 in 2
	9	1 in 3
High: Repeated failures	8	1 in 8
	7	1 in 20
	6	1 in 80
Moderate: Occasional failures	5	1 in 400
	4	1 in 8000
	3	1 in 15000
Low: Relatively few failures	2	1 in 150000
	1	<1 in 150000

Table 3. Detection Method **(**Wang *et al.*, 2009)

Detection	*Rating*	*Possible detection by controller*
Absolute Uncertainly	10	There is no controller that is capable of detecting the cause of failure and subsequent failure modes.
Very Remote	9	The ability of the controller is very small in detecting the cause of failure and subsequent failure modes.
Remote	8	The ability of a small controller to detect the cause of failure and subsequent failure modes.
Very Low	7	The ability of the controller is very low in detecting the cause of failure and subsequent failure modes.
Low	6	The ability of the controller is low in detecting the cause of failure and subsequent failure modes.
Moderate	5	The ability of the controller is moderate in detecting the cause of failure and subsequent failure modes.
Moderately High	4	The ability of the controller is very moderate in detecting the cause of failure and subsequent failure modes.
High	3	The ability of the controller is high in detecting the cause of failure and subsequent failure modes.

2.2 Risk Priority Number (RPN)

Risk Priority Number (RPN) is the value that results from the multiplication of the severity, incidence rate and detection rate. The Risk Priority Number determines the priority of failure. The higher the RPN value, the more problematic it shows. The RPN value is used to rank the process failure. RPN formula (S = severity, O = occurrence, D = detection)

$$\mathbf{RPN = S \times O \times D}$$

3. METHODOLOGY

In this research, the first stage is the direct observation to identify existing problems. The procedure or steps used can be seen as follows:

3.1 Data Collection

Data collection is carried out in the following stages:

a. Observation is used to study the existing problems
b. Interview to determine the attributes of the related supply chain elements.
c. Distribution of questionnaires to determine the data processed.
d. Literature study to determine the processing of clam and seaweed.

3.2 Data Processing

Data processing is carried out in the following stages:

a. Failure Mode and Effect Analysis (FMEA). Identification of risk events and risk agents using FMEA (Failure Mode and Effect Analysis) method to determine the weight of each occurring risk and select the element risks with the highest weight.
b. Analysis is used to determine the highest risk of each element of the supply chain network
c. The conclusion is a brief statement that outlines the results of research and discussion to prove the hypothesis or answer the objectives of the study.

4. RESULTS AND DISCUSSION

4.1 Kerula Supply Chain Network

The supply chain network currently studied follows the figure below, where there is one supplier of seaweed and one supplier of clams. The agent buys shellfish and seaweed from the two suppliers.

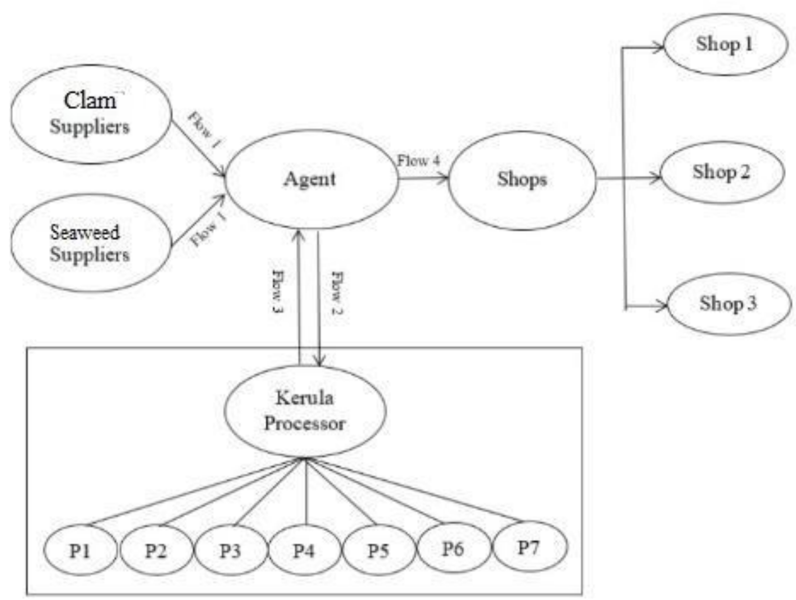

Figure 2. Product Supply Chain Flows

Explanation:
Clam Collector : Sells tens to thousands of kilos of clam
Seaweed Collector : Sells tens to thousands of kilos of seaweed

Agent : Distributes clam and seaweed to kerula processor to be processed and gives flavor variants to the finished and avalaible kerula packages.
Kerula Processsor : Turns clam and seaweed to kerula and returns it back to the agent.

Flow 1 : The flow of goods between collectors and agent where agent buys the raw material to from the collectors.
Flow 2 : The flow of goods between agent and processor where agent gives the raw material to the processor.
Flow 3 : The flow of goods where the processor gives kerula to the agent.
Flow 4 : The flow of goods between agent and sellerr where agent gives the kerula product to be sold.
P1-P7 : The number of craftment that work with the processor in manufacturing kerula.
Shop1 – shop3 : Shops that sell kerula

Table 4. RPN Values Result of SME Kerula Supply Chain Network
(S = severity, O = occurrence, D = detection)

Element	Impact Variable	(S)	(O)	(D)	RPN	RPN Total
Seaweed collector	Poor raw material quality	5	5	5	125	550
	Delay in Supply from suppliers	4	6	4	96	
	Irregular supply from suppliers	5	5	5	125	
	Poor seaweed quality	3	4	4	48	
	Product loss/ weight loss	4	5	5	100	
	Complaints about the product	4	4	3	48	
	Product return	2	2	2	8	
Clam collector	Poor raw material quality	5	5	5	125	550
	Delay in Supply from suppliers	4	6	4	96	
	Irregular supply from suppliers	5	5	5	125	
	Poor clam quality	3	4	4	48	
	Product loss/ weight loss	4	5	5	100	
	Complaints about the product	4	4	3	48	
	Product return	2	2	2	8	
Kerula processor	Damaged equipment during processing	7	5	5	175	919
	Poor quality of kerula crackers	3	3	3	27	
	Damage due to pests (rat/fly)	4	4	1	16	
	Delay in product delivery to the agent	4	4	3	48	
	Damaged raw material	2	2	2	8	
	Injury during processing	2	2	2	8	
	Difficulty in acquiring raw materials	7	7	5	245	
	Difficulty to market the resulting products	7	7	8	392	

Agent/Store	Increase in fuel prices	4	2	2	16	700
	Increase in basic electricity rates	5	3	3	45	
	Damaged packaging during delivery	7	5	5	175	
	Difficulty to sell the product	8	8	7	448	
	Product loss	2	2	2	8	
	Complaints about the product	2	2	2	8	

The table above shows the RPN value of each element of the supply chain management(SCM) network, namely the seaweed collectors, which total RPN value is 550, the clam collectors which total RPN value is 550, kerula processor which total RPN value is 919, and the agent / shop which total RPN value is 2035. From said values, we know that the element of SCM network that has the greatest risk is the agent / shop with total RPN value of 2035.

4.2 RPN Value Analysis of Each Supply Chain Network

Based on the processing results, the overall RPN value of each supply chain management (SCM) network is used to determine which network has the highest and lowest RPN impact variable values.

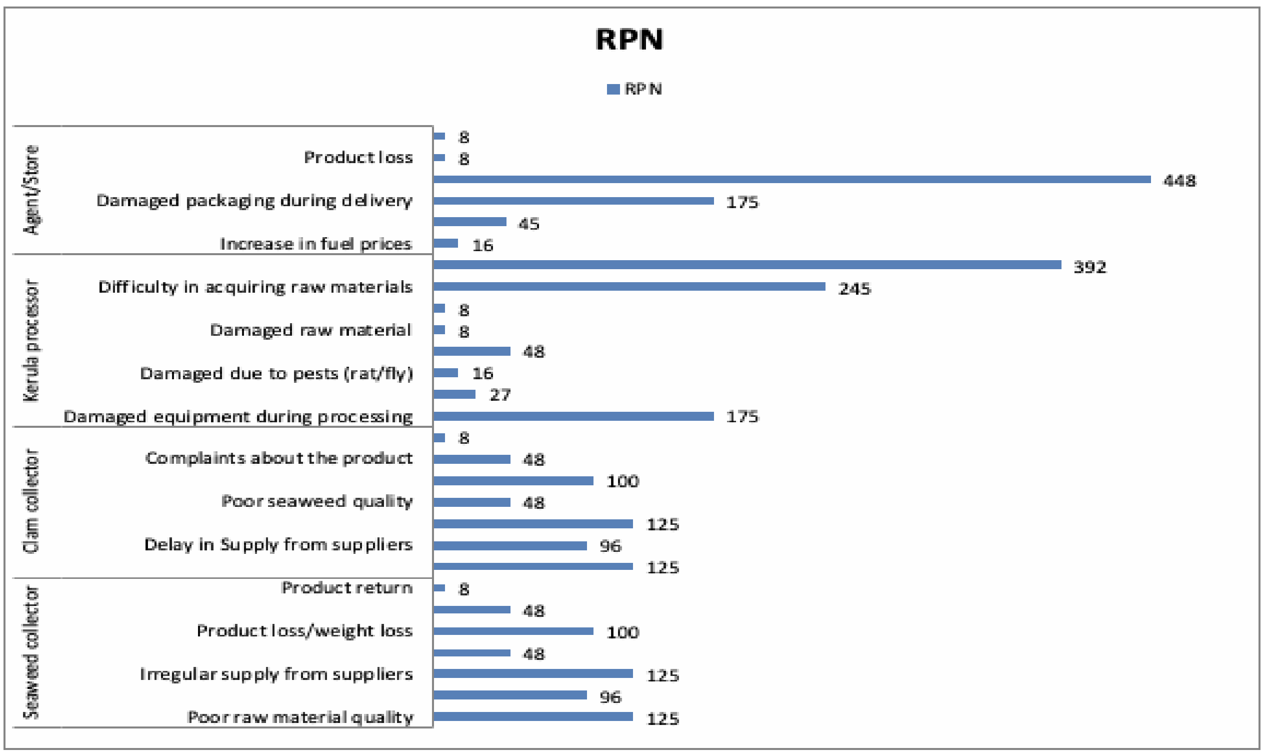

Figure 3. Impact Variable Diagram

Based on Figure 3 it is known that the highest RPN (Risk Priority Number) value is in the Agent / Store supply chain namely the Difficulty to sell the product criteria (RPN=448), this is because Kerula is a new product that still requires a lot of advertising or marketing to introduce it to consumers. The marketing problem was also encountered by the processor supply chain because the largest RPN value was also in this criterion (RPN = 392) besides the raw material acquisition problem (RPN = 245) which is the second biggest of risk faced by processor. As for the clam collector and seaweed collector supply chains, the biggest risk is the poor quality of raw materials and irregular supply (RPN = 125).

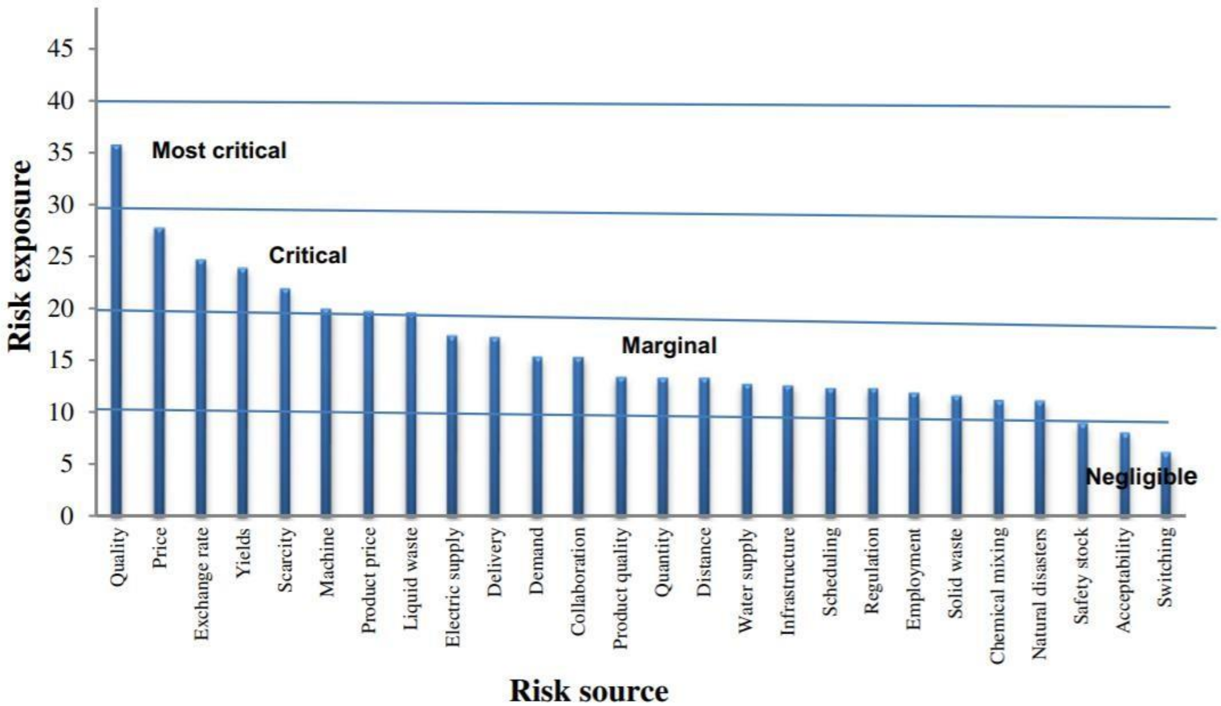

Fig. 4 A pareto chart of risk sources in a carrageenan supply chain (Mulyati and Geldermann, 2016)

From figures 3 and 4, it is shown there is several point can be compared between previous research (Mulyati and Geldermann, 2016) and current researche. Such points are: quality, price, and delivery. In the previous research, quality has value of 36 where as quality in the current research has the higher value of 48. Such value is due to the Severity, Occurance and Detection values of 3, 4, and 4 respectively. Whereas 3 means the system of kerula business can operate with some decreased performance. Value 4 of occurance lies on level *moderate*: occasional failures. And value 4 of detection means the ability of the controller is very moderate in detecting the cause of failure and subsequent failure modes.

In the meantime, in the previous research, price has the value of 28 whereas price in the current research has the value of 16. Price value comes from Severity, Occurance and Detection which is 4, 2 and 2, respectively. Severity value of 4 means the system can operate with some decreased performance. Occurance value of 2 lies on *Low* level: Relatively few failures, whereas Detection has value of 2 which is the ability of the controller is high in detecting the cause of failure and subsequent failure modes.

Final aspect which is compared that is Delivery. In the meantime, current research has high delivery value of 175, compared to previous research which has value of 18. Value of 175 is obtained from multiplication among Severity, Occurance and Detection which has value of 7, 5 and 5, respectively. Severity value of 7 means that the system cannot operate with equipment damage. Occurance value of 5 means delivery get into *Moderate* level: Occasional failures. And detection value equal to 5 since the ability of the controller is moderate in detecting the cause of failure and subsequent failure modes.

5. CONCLUSION

Based on the research objectives, the results of data processing, discussion, analysis and given recommendations, there are several conclusions:

1) To reduce the occurring risks and maximize performance of each element of the supply chain management (SCM) network, the FMEA method shows the RPN value with the highest and lowest impact variables of each element of SCM network. As a new product, kerula faces its biggest supply chain risk at the agent / shop that sells its products, so a large enough effort is needed to help its marketing process to make it known better by the consumer. While the biggest risks faced by the collector are the difficulty to acquire raw materials and irregular supply of raw materials.
2) UKM Kerula has 4 elements of supply chain management, they are the clam and seaweed collector who collects from people who sell it, the agent who buys from the collector, and gives it to the processor who turns them into kerula, and finally, the seller who sells the products to the consumer.
3) The highest RPN value is at the collectors, with a total of RPN value of 448
4) This research correspond to the previous research (Heti and Geldermann, 2016)

5.1 RECOMMENDATIONS

Based on the result, the following are recommended:

1. Handling the commonly occuring risks such as the selection of good raw materials.
2. Storing kerula in dry place with enough lighting.
3. Stored kerula should be dry to avoid damage and mold.
4. Proposals will be given to reduce occuring risks so as to maximize performance, and also to increase the added value received by each element of the supply chain management network. The FMEA method shows the results of the RPN value so that the highest impact variable of each SCM network is obtained, as follows:

Impact Variable	RPN	Recommendation
Difficulty to sell kerula products	448	- Repairing the selling system of kerula products
Damaged packaging during delivery Damaged equipments during processing	175	- Changing the packaging to protect the product inside from damage. - Repairing the equipments during processing
Difficulty to market the resulting products	392	- Repairing the marketing system
Difficulty to acquire raw materials	245	- Changing the supplier selection system to ease raw material acquirement

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