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Analysis and Mitigation Strategies of Croissant Production at PT XYZ

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ABSTRACT

This purpose of this research is to identify risk, analyzes risk priorities, and formulate alternative strategies and determine the priority strategies that can be applied to minimize the risk in production process of croissant at PT XYZ. The methods used in this research were the Failure Mode and Effect Analysis (FMEA) method and Analytical Hierarchy Process (AHP). The FMEA method is used to asses and determine risk priorities, while the AHP method is used to determine the priority of risk mitigation strategies. Based on the result, there are 19 risks which are divided into 3 risk factors, namely: raw materials, production process, and deliveries. The result from risk assessment and determination of risk priorities were the risk that have a high-Risk *Priority Number* (RPN), namely the risk of damage to raw materials during storage in the warehouse (52.6), machines and equipment are not working optimally (292.3), and delivery vehicles have problems (73.1). Priority strategies that can be used to minimize risk, namely on raw material risk factors are to make improvements to the placement and separation of clear types of raw materials (0.384), while in the production process risk factor are to replace machines and equipment that have a long life (0.435), and in delivery risk factor is to improve performance control and maintenance of vehicles on a regular basis (0.610).

KEYWORDS: Risk analysis, risk mitigation, FMEA, croissant

I. INTRODUCTION

Industry is basically an economic activity that processes raw materials into goods that have more added value or have higher benefits. The food and beverage industry are one of the important industrial sectors [1] and contributes greatly to the economy in Indonesia. Data from the Ministry of Industry of Indonesia shows that the growth of the food and beverage industry in the second quarter of 2018 reached 8.67 percent or exceeded the national economic growth of only 5.27 percent. One of the food industries in Bali is a bakery and PT XYZ is a bakery that has been established since 1998. Croissant is the favorite bread that is always ordered every day by customers of PT XYZ and produced around 500-1000 croissants per day. Croissant is bread originating from France, it has a multilayered texture [2] and has the shape of a crescent moon.

According to [3], risk is the impact of uncertainty on objective achievement (the purpose of a company). Every company has never escaped uncertainty or risk, as well as PT XYZ, which has never escaped the risk of producing croissants. The risk of producing croissant is uncertainty that can cause losses, such as: product defects due to non-uniform size, mistakes in making dough, and unmet demand due to non-existent raw materials. The amount of damage to croissant is currently estimated at 15-30 breads or about 3 percent of the total production. Risk in the company must be managed properly, and one of its efforts is through risk management.

Risk management is a structured and systematic process in identifying, measuring, mapping, developing risk management alternatives, monitoring risk management, and controlling risk management. Failure Mode and Effect Analysis (FMEA) is one of the methods in risk management. The FMEA method is a procedure or technique used to define, identify, and eliminate potential failures from the process [4]. The advantage of the FMEA method compared to other methods is that it can take priority actions and steps taken by looking at the effects of failure of each production process, so that the company can more easily control the production process and minimize defects. Furthermore, FMEA method is integrated with the Analytical Hierarchy Process (AHP) method to analyze the priority of risk mitigation strategies. AHP method is used to determine the priority of mitigation strategies by using pairwise comparison. The purposes of this study are: identify the risks in the production process of croissant, analyze the priority risk in the production process of croissant, and formulate alternative strategies and determine the priority strategies that

can be applied to minimize the production risk of croissant at PT XYZ.

II. METHODS

The research was conducted at PT XYZ, located at North Kuta, Badung, Bali and analyses data were carried out in Industrial Engineering Laboratory, Department of Agro-industrial Technology, Faculty of Agricultural Technology, Udayana University. The stages of the study consisted of preliminary surveys, identification of problems and objectives, determination of respondents, preparation of questionnaires, data collection, and data analysis. Expert respondents for this study were three bakery supervisors, a former general manager, and an academic. There were four questionnaires used in this research and arranged based on their objectives, namely: questionnaire I for identifying risks, questionnaire II for risk assessment, questionnaire III for formulating alternative risk mitigation strategies, and questionnaire IV to determine the priority of risk mitigation strategies. The data were obtained from observation, interviews, questionnaires, and literature studies.

Analysis of data in research is divided into 3 stages: (1) risk identification, (2) risk assessment analysis and risk priority determination, and (3) formulating the alternative strategies and determining the priority of risk mitigation strategies. Risk identification is done by interviews and also observations at each stage in the production process of croissants. The results of the interviews and observations were discussed using descriptive and tabulation methods. The risks that have been identified are then assessed and determined by risk priorities through the Failure Mode and Effect Analysis (FMEA) method. Each risk is assessed based on the 3 factors of severity (S), occurrence (O), and detection (D) on a scale of 1-10 [5]. Severity is an assessment of the effect or the impact of a potential failure mode [6], occurrence reflects the probability or frequency of failure occurring [7], and detection is the chance of failure that can be detected. Because the expert respondents in this research are more than 1, then the values of S, O, D are obtained from the calculation of geometric mean [5]. The value of each factor is then used to determine the Risk Priority Number (RPN) by multiplying 3 factors (severity, occurrence, and detection) [8]. The RPN is sorted from the largest to the smallest to get the risk priority [9].

The next stage is the formulation of alternative risk mitigation strategies by interviewing using questionnaire III. The alternative risk mitigation strategies that have been formulated are then prioritized using the Analytical Hierarchy Process (AHP) method. The stages of analysis in the AHP method are divided into four parts, namely: compiling hierarchies, evaluating criteria and alternatives, determining priorities, and determining logical consistency. The weight of the scores in the pairwise comparison was given by expert respondents through the questionnaire IV. Pairwise comparisons are made by assessing the importance of one element to other elements using a comparison scale of 1-9. The highest value generated from the pairwise comparison is the chosen mitigation strategy to minimize the risk in the production process of croissant. Data processing in the AHP method using software Expert Choice 11.

III. RESULT AND DISCUSSION

A. Risk Identification

Risk identification of croissant production is done by interviewing expert respondents and also observation at each stage of production. Risk identification results are grouped based on raw materials, production process, and delivery. Risk grouping into risk factors is based on similarity of characteristics and aims to facilitate risk identification and also in determining risk mitigation strategies. The results of risk identification can be seen in Table 1.

Table 1. Identification of risks in croissant production at PT XYZ

No.	Risk Factor	Risk	
1	Raw material	1.1	Stock of raw materials does not exist
		1.2	Mistakes of suppliers in sending raw materials
		1.3	Raw material damage during storage in the warehouse
		1.4	Damage of raw materials when transferring to a production room
2	Production process	2.1	Workers error during weighing
		2.2	Workers error in making dough
		2.3	Uneven butter
		2.4	non-uniform size of croissant
		2.5	The distance of croissants in the baking tray is too close
		2.6	Croissant is not glazed with eggs
		2.7	Croissant are too long or too briefly placed in the proofer machine
		2.8	Baked croissants for too long
		2.9	The temperature of the oven is unstable
		2.10	Croissant fell from the baking sheet
		2.11	Contamination of waste (unused)

		2.12	The room for forming a croissant is not cold
		2.13	Machines and equipment do not work optimally
3	Delivery	3.1	Delivery vehicles have problems
		3.2	Damage during shipping

There are 19 risks of croissant production that have the potential to cause a loss to the company and are divided based on 3 risk factors (Table 1). In the raw material risk factor there are 4 risks, in the production process risk factor there are 13 risks, and in the delivery risk factor there are 2 risks.

B. Risk Assessment and Determination of Risk Priorities

Title the risks are then assessed through 3 criteria, namely severity (S), occurrence (O), and detection (D), and then the three criteria are multiplied to obtain RPN. The results of the risk assessment using the FMEA method and the calculation of the RPN shown in Table 2. Based on the results of the RPN calculation, the risk that has a high value and ranks first on the raw material risk factor is raw material damage during storage in the warehouse (RPN = 52.6). Damage during storage of raw materials, for example raw materials are too long stored, causing the raw material to exceed the expired date. Furthermore, the arrangement of raw materials that are less noticed makes some raw materials quickly damaged. The impact of this risk is that damaged raw materials cannot be used for croissant production.

On the production process risk factor, the highest RPN is 292.3 at the risk of the machine and equipment not working optimally. The machines and equipment used in the production process of croissants are generally long-lived or have exceeded the economic life of the machine, such as dough sheeter machines, ovens, and mixers which are around 10-15 years old. The perceived impact of this risk is that the engine and equipment are damaged, which disrupts the production process, especially when the engine is damaged at night.

Table 2. Assessment of the risk in croissant production at PT XYZ and RPN calculation

No.	Risk Factor	Risk	S	O	D	RPN	*Rank*
1	Raw material	1.1 Stock of raw materials does not exist	5.7	2.9	2.4	39.5	2
		1.2 Mistakes of suppliers in sending raw materials	4.1	2.4	2.0	19.3	4
		1.3 Raw material damage during storage in the warehouse	6.4	2.0	4.0	52.6	1
		1.4 Damage of raw materials when transferring to a production room	3.6	2.8	3.0	29.9	3
2	Production process	2.1 Workers error during weighing	7.7	3.2	5.2	130.9	5
		2.2 Workers error in making dough	8.4	3.1	4.4	113.5	6
		2.3 Uneven butter	7.6	4.8	4.5	161.2	3
		2.4 non-uniform size of croissant	5.3	6.0	3.3	105.2	7
		2.5 The distance of croissants in the baking tray is too close	5.5	3.1	2.6	44.2	12
		2.6 Croissant is not glazed with eggs	6.2	2.9	2.6	46.5	11
		2.7 Croissant are too long or too briefly placed in the proofer machine	6.8	2.9	3.8	73.7	10
		2.8 Baked croissants for too long	6.6	3.4	3.7	84.3	8
		2.9 The temperature of the oven is unstable	7.5	5.3	4.5	178.8	2
		2.10 Croissant fell from the baking sheet	7.9	2.7	3.5	74.5	9
		2.11 Contamination of waste (unused)	4.0	1.4	1.9	10.9	13
		2.12 The room for forming a croissant is not cold	7.7	4.0	4.5	138.1	4
		2.13 Machines and equipment do not work optimally	8.6	6.7	5.1	292.3	1
3	Delivery	3.1 Delivery vehicles have problems	6.5	2.8	4.0	73.1	1
		3.2 Damage during shipping	7.0	2.9	3.2	66.7	2

Remarks: Severity (S), Occurrence (O), Detection (D), Risk Priority Number (RPN)

The risk that has the highest rating on the delivery risk factor is delivery vehicles having a problem with RPN of 73.1. The impact of this risk is to hinder the delivery process. Risks like this are usually caused by the vehicle engine being damaged or broken when sending. Every risk that has been sorted from the lowest to the highest certainly has the opportunity to

disrupt the production and then cause losses to the company. These risks must then be sought for solutions in order to reduce or mitigate the effects of the losses generated by these risks.

C. Formulation of Alternative Strategies and Determination of Priority Risk Mitigation Strategies

Risk assessment has resulted the prioritized risks, then solutions are taken that can reduce the impact of these risks. The stage begins with the formulation of alternative mitigation strategies through interviews with expert respondents as well as providing input to the company regarding several alternative mitigation strategies that can be done. The formulation of an alternative mitigation strategy for the risk in croissant production can be seen in Table 3.

Table 3. Formulation of alternative risk mitigation strategies in croissant production at PT XYZ

The aim		Minimizing risk croissant production	
No.	Risk Factor	Alternative Risk Mitigation Strategies	
1	Raw material	S1.1	Make improvements to the FIFO (First in First Out) system
		S1.2	Make improvements to the placement and separation of raw materials clearly
		S1.3	Make improvements in material handling
		S1.4	Make improvements to the raw material planning system
		S1.5	Make improvements to stock controlling
2.	Production process	S2.1	Make replacements for machines and equipment that have a long life
		S2.2	Improves performance control and routine maintenance of machinery and equipment
		S2.3	Create and apply SOP in the production process
3.	Delivery	S3.1	Improve performance control and maintenance of vehicles on a regular basis
		S3.2	Make a replacement for machine components periodically
		S3.3	Make improvements in material handling

The results of the formulation of alternative mitigation strategies are then continued to determine the priority of risk mitigation strategies that can be applied in companies using the AHP method. In the AHP method, it still involved 5 expert respondents namely 4 expert respondents from the company and 1 expert respondent from academia. Each expert respondent then assesses by giving a value to the questionnaire for each criterion, which in this study is a risk factor and also an alternative risk that exists. The evaluation of each respondent is then processed using expert choice software. The highest weight value is the risk mitigation strategy chosen to be implemented to minimize the risk of croissant production at PT XYZ.

The ratio consistency value (CR) that can be seen in Table 4 is a benchmark for the consistency of the pairwise comparison results of a matrix. Consistency ratio (Table 4) for the purpose of minimizing the risk of croissant production which is 0.01, consistency ratio for raw material risk factors is 0.03, consistency ratio for production process risk factors is 0.00, consistency ratio for shipping risk factors is 0 .00. All consistency ratios have values smaller than 0.1 (<0.1) or 10%, indicating that the weighting results of the five expert respondents are considered to have acceptable consistency [10] and no repetition is needed [11].

In the AHP method it is important to make a hierarchical structure to make it easier to solve problems. Hierarchy is a representation of complex problems and is broken down into a multilevel structure where the first level is the goal, followed by the level of factors, criteria, sub criteria, and so on down to the last level of alternatives. Hierarchy will make a complex problem appear more structured and systematic. The hierarchical structure of the risk mitigation strategy of PT XYZ croissant production in Figure 1 is divided into 3 parts, namely; objectives, criteria (risk factors), and alternatives which are risk mitigation strategies.

Table 4. Consistency ratio (CR) of expert respondents for priority risk mitigation strategies in croissant production at PT XYZ

No.	The Aim and Risk Factors	Ratio consistency (CR) (CR < 0.1 = consistent)
1.	Minimizing risk in croissant production	0.01
2.	Raw Material	0.03
3.	Production process	0.00
4.	Delivery	0.00

The comparison between risk factors / criteria (Figure 1) shows that the highest production process risk factor is 0.622. This value indicates that the production process is the most influential criterion among other criteria according to expert respondents. The production process is highly emphasized on activities in the process of making products and leads to labor, machinery, and methods. The process of producing croissant goes through many stages that must be considered in detail in order to produce quality croissant bread. PT XYZ in the

production process uses the help of tools and machines, such as: ovens, scales, mixers, chillers, dough sheeters, pans, rack compilers, proofers, etc., but some of the machines used are old so machine performance decreases and often having damaged. One of the determinants of the success rate of bread made is the smooth operation of the machines and equipment used. Therefore, it is necessary to propose a number of risk mitigation strategies that can be applied at PT XYZ, especially on the risk factors of the production process because they receive the highest weighting value.

The results of comparisons between alternatives on the raw material criteria, the strategy that gets the highest value is the strategy to make improvements to the placement and separation of raw material types clearly with a value of 0.384. A good warehousing system is a warehousing system that is able to utilize space for storage effectively in order to increase space utilization and minimize material handling costs [12]. The warehouse in PT XYZ still has problems in terms of placement of raw materials that are still not well ordered. This can cause the process of taking raw materials in the warehouse to be hampered and also a waste of time and place (space). In addition, another problem is that the warehouse in PT XYZ is still used as a storage area for chemicals such as cleaning agents for the production room. This can cause raw materials to become easily damaged and polluted. Storage of raw materials in warehouses must be based on these types of raw materials. Therefore, improvement is needed in terms of the placement of raw materials in the warehouse and also the separation between the various types of raw materials clearly.

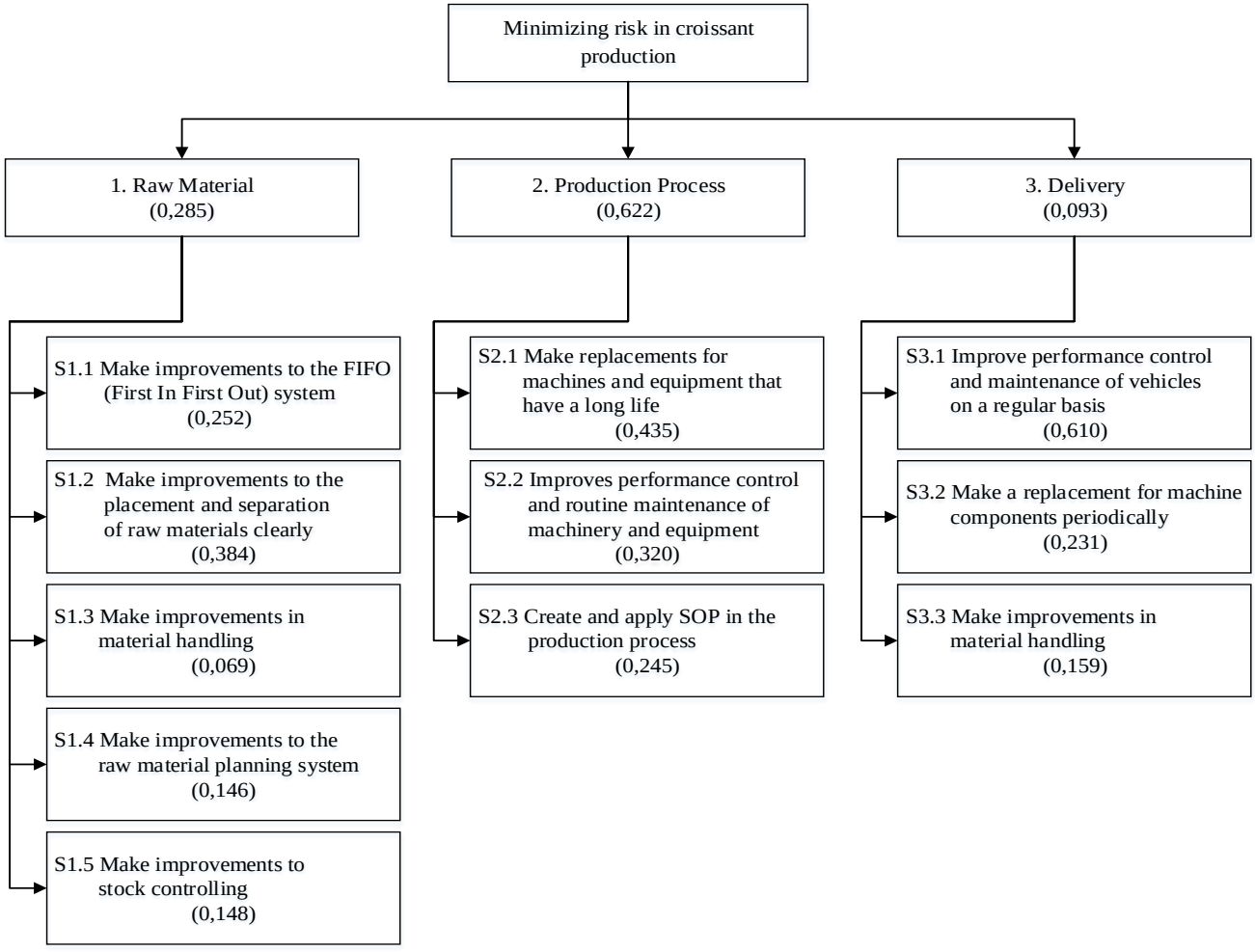

Figure 1. The hierarchy structure of the risk mitigation strategy in croissant production at PT XYZ

In the comparison between alternatives based on the criteria of the production process, the calculation results show that the strategy of replacing machinery and equipment whose age is long is the most important strategy with a value of 0.435. The machines in PT. XYZ, on average, are indeed old, i.e. 10-15 years and often suffer damage. These machines include an oven, mixer, chiller and dough sheeter. Oven and mixer machines have an economic life of 8 years, this also applies to dough sheeter and chiller machines. So far, the company has done checks and repairs to machines that have been damaged, in addition to that the company has also made replacement of damaged engine components. Production machinery and equipment will decrease their performance and efficiency over time, therefore replacing machines with new ones needs to be done [13]. Replacement of machinery and equipment that has long been required to be applied at PT. XYZ given the age of the machine that has exceeded its useful life and often suffer damage, in addition to replacing

the engine can also increase efficiency and save operating costs and engine maintenance.

The results of calculations on delivery criteria, strategies to improve performance control and maintenance of vehicles on a regular basis is the strategy chosen and has the highest value compared to other strategies, namely 0.610. Control of vehicle performance must be carried out routinely before the vehicle is ready to be used for shipping, it must also be done in conjunction with vehicle maintenance. The problematic vehicle engine is fatal, because the delivery process is hampered and customer orders are late. At PT XYZ itself, care is taken of the vehicle, but only if the vehicle's engine is damaged. The absence of maintenance scheduling causes unpredictable engine damage, therefore a preventative vehicle maintenance schedule is needed. Improved performance control and vehicle maintenance can also be done by checking the condition of the vehicle just before the delivery process

IV. CONCLUSION

1. Identification of the risk of croissant production at PT XYZ produces 19 risks which are divided into 3 risk factors, the raw material risk factors are 4 risks, the production process risk factors are 13, and the delivery risk factors are 2 risks.
2. Priority risk is the risk factor for raw materials, namely the risk of damage to raw materials during storage in the warehouse (52.6), while the risk factors for the production process are the risk of machinery and equipment not working optimally (292.3), and the shipping risk factor namely problematic delivery vehicles (73.1).
3. The priority strategy for raw material risk factors is to make improvements to the placement and separation of raw material types clearly (0.384), while the risk factor for the production process is to replace machines and equipment whose age is long (0.435), and to risk factors delivery is to improve performance control and maintenance of vehicles on a regular basis (0.610).

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