Integration of Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA) Method of Tea Product Packaging

M A L Rucitra and Amelia J
Department of Agro-industrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia. Email: andanrucitra@ub.ac.id

Abstract. The packaging is a container or wrapper that is useful for preventing or minimizing damage to packaged products. Industry X is one of the companies engaged in beverage packaging, and the important thing is to adjust the packaging's quality of the products. The first primary packaging of tea products is preform that is a semi-finished plastic bottle with PET, its small and light shape causes the preform to be widely used by companies because it can reduce transportation costs. Quality control is carried out by the company so that the products are following predetermined standards and following the consumers' expectations. The purpose of this research is to reduce the disability that occurs so that the productivity of the company increases. To solve this problem using statistical quality control (SQC) and any analysis of failure modes and effects (FMEA). From the research conducted using SQC, the results show that the highest amount of damage occurred in February of 3.95%. While the results of the risk analysis using FMEA showed that defective preform was the main risk that needed to be controlled because it had an RPN of 294 due to supplier errors.

1. Introduction
Tea is one of the non-alcoholic drinks consumed in large enough quantities by the people of Indonesia. Tea is a type of beverage made from young shoots that have undergone processing. The benefits of drinking tea are that it can give a fresh taste, can restore body health and has been shown not to cause negative effects if consumed regularly [1]. Industry X is an industry engaged in the beverage sector. One product that is produced is bottled tea drinks with the basic ingredient is oolong tea. This product is packed with primary packaging made from plastic which is then packaged in secondary packaging in the form of cardboard.

In the beverage industry production system, packaging becomes a fundamental thing and is very important to note. Direct packaging will be closely related to the quality of a beverage product produced. Packaging maintains the quality of the drink from contact with the surrounding environment so that contamination can be prevented. The process of quality control in packaging is something that must be done as a form of responsibility of an industry to maintain the quality of its products. Packaging becomes important because it is used to protect products, besides packaging is considered a company's strategy to present products that are more attractive in terms of shape and colour so that product quality can be maintained. The quality of packaging can be seen from the packaging material, the form of packaging and labelling of packaging [2].

Statistics Quality Control (SQC) as a production quality control tool can help companies whether the products produced are still within the limits of control or not from the initial process of quality ingredients, product processes, final products [3]. Quality control is carried out by the company so that the products produced are in accordance with established standards and in accordance
with consumer desires. There are 2 methods that can be done in testing using SQC, namely pareto charts and fishbone diagrams to obtain. While the FMEA method is used to identify the stages of the process that caused the failure to occur [4]. This risk analysis using FMEA aimed to reduce the disability that occurs so that the productivity of the company increases.

2. Materials and Methods
This research was conducted in industry X. Data processing was carried out at the Laboratory of Computing and Systems Analysis of the Department of Agricultural Industry Technology, Faculty of Agricultural Technology, Brawijaya University, Malang. The method used in this study is the Statistical Quality Control (SQC) method and the Failure Mode and Effect Analysis (FMEA) method, with the research material being primary packaging tea in packaging.

Data processing is carried out if the required data is fulfilled, and processed using Pareto charts, fishbone diagram and FMEA methods, with the following steps:
1. The research began by conducting surveys and interviews in Industry X. Preliminary surveys and interviews aimed to find out the actual condition of the company that can be used in the formulation of problems that exist in the company and can provide clear direction steps taken next by researchers
2. P control chart
Data related to quality control of tea packaging is taken from a number of tea packaging processes carried out by industry X which are influential attributes to the P control chart for product packaging data that is not in accordance with company standards. The use of P control chart for defective packaging products with the formula:

\[ p = \frac{\text{Defect}}{\text{Production}}, \quad \text{Sp} = \sqrt{\frac{p(1-p)}{n}} \]

If the calculation results show that the process is not under control, the process will be improved
3. Pareto Chart
Pareto chart is a bar chart that shows the problem based on the order of the number of events from the number of problems that occurred the most until the least occurred. In this study, it is used to find out the damage data of tea products from industry X, and the defects that often occur in the tea packaging process
4. Fishbone Diagram
Fishbone Diagram is one method to improve quality. The steps taken are to determine the problem that will be observed in the diagram (preform defects, foreign material, cap damage, conveyor problems).
5. Failure Mode Effect Analysis (FMEA)
The steps in making an FMEA table are to write down all the main steps of the tea packaging process carried out by industry X. In the first column, make a list of potential failures (failure modes) for each step of the packaging process, make a list of the effects of failure modes in the previous list, determine rating on the value of S (severity), O (occurrence), and D (detection). The final step is to multiply the numbers in the 'S' (severity), 'O' (occurrence), and 'D' (detection) columns then the results are entered in the 'RPN' (risk priority number) column. The highest RPN value gets the highest priority scale for improvement. The following table will present a table of S (severity), O (occurrence) and D (detection) values.

3. Result and Discussion
3.1. Pareto Chart
Based on direct observations in 2018 using sampling. Samples are taken periodically from the output of the production process. The cause of failure can come from operators, machines or raw materials. Quality control from the control of raw materials to finished products has been carried out by the company but there are still products that are damaged during the production process. Data on total production and number of products damaged in 2018 can be seen in Table 1.
It can be seen that the greatest amount of damage was found in January at 3.84% and February at 3.95% (Table 1). This damage can be affected due to operational processes at the beginning of the year that cause machine performance and worker performance is still less than optimal. In addition, the most damage occurred in January and February 2018 because in that month it was the rainy season with very large rainfall. This rainy season indirectly affects the quality of preform stored in storage sheds. The weather tends to be humid in the rainy season causing preforms that are stored have a high humidity level as well. So that during the blowing process, the preform becomes fragile and easily damaged because it contains high water content. Based on data on the number of production and damaged products, it can also be seen that the largest types of damage occurred during the tea production process in 2018. A Pareto diagram can show the most types of damage on the primary packaging of tea products (Figure 1).

From the four types of damage to the primary packaging of tea products during January-December 2018, it can be seen that the highest damage is in the defective preform. The number of defective preforms is 48.7%. Then for stamp damage the amount is 27.9%, for damage due to foreign material the amount is 13.2% and damage in the conveyor amount is 10.1%. It can be said that the company needs to control the problem of preform defects even deeper because of its considerable impact on the amount of damage to the primary packaging of tea products. Control can be done...
starting from handling raw materials to finished products. Quality standards are raw materials, production processes and finished products. Therefore, quality control activities can be started from raw materials, during the production process takes place until the final product will be adjusted to the standards that have been made [5]. Preforms that are defective due to a defect in the preform itself can be controlled by conducting more stringent supervision during the incoming process or receiving raw materials at GMT and monitoring during preform storage. The preforms imported by the supplier must be checked more carefully so that if there is damage one can immediately make a complaint to the supplier. In addition, the preform storage temperature and preform storage period must be paid more attention so that no preform has high humidity. Because preforms that are too moist will become deformed when blowing in the production process.

3.2. Fishbone Diagram

Cause and effect diagrams show the relationship between the problem at hand and its possible causes and the factors that influence it. The function of this diagram is to recognize the root cause of a problem or the underlying cause of a particular effect, problem, or condition. This diagram also serves to sort out and describe the interplay between various factors that influence a particular process. While the benefits of this diagram are to increase knowledge about the process being analyzed and learn more about work factors and how these factors are interrelated. The cause and effect diagram of damage to the primary tea packaging can be seen in Figure 2.

Fig. 2. Cause and effect diagram of primary tea packaging

3.3. Failure Mode and Effect Analysis (FMEA)

Alternative proposed improvements that will be given refer to the results of the FMEA method. The FMEA method is used to select the most dominant risk in causing failure in the tea packaging process. Based on the seven risks that have been obtained from the fishbone diagram, interviews are then conducted with the head of packaging and five alternative improvements are chosen that are most suitable for the company's ability to solve these problems (Table 2).

In the calculation of risk, the first thing to do is to provide assessment criteria at the level of severity, occurrence, and detectability from level 1 to 10 by experts or employees who are experts in the field. In this case the author uses four experts namely industry X quality control employees to fill in the assessment criteria, because all four people are responsible for the quality of the packaging quality. The selection of respondents must be based on the consideration that the respondent, has a
direct relationship with the process and is an employee who has long work experience [6]. After filling the questionnaire, the processing results obtained using FMEA as in Table 3.

Table 2. Risk process of the tea packaging

| No | Risk process | Possible Effect | Possible cause | Control |
|----|--------------|-----------------|----------------|---------|
| 1  | Less pressure during the blowing process | Dented bottle | Lack of amount of nitrogen pressure released | check and ensure that the measurement |
| 2  | The bottle fell from the conveyor | Bottle falls | Bottles that fall from the conveyor because too many bottles in the conveyor | regulate the number of bottles produced so that the bottles arranged in the conveyor are not crammed and are not easily dropped |
| 3  | High humidity in the environment | Preform defect | High preform humidity levels | Pay attention to room temperature and preform placement |
| 4  | Preform Defect | Preform defect | supplier error | Handling raw materials properly during the incoming process, |
| 5  | Odd Materials | There are odd materials in the preform | Process of forming the preform from the supplier | Handle the right raw materials during the incoming process |

Table 3. Risk calculation using FMEA

| No | Risk identify | S | O | D | RPN |
|----|---------------|---|---|---|-----|
|    |               | 1 | 2 | 3 | 4  | 1 | 2 | 3 | 4  |
| 1  | Preform Defect | 8 | 7 | 5 | 4  | 7  | 7 | 7 | 7 | 6  | 6  | 7 | 9 | 294 |
| 2  | The bottle fell from the conveyor | 9 | 5 | 5 | 4  | 7  | 6 | 5 | 6 | 3  | 7  | 6 | 6 | 189.75 |
| 3  | High humidity in the environment | 9 | 6 | 5 | 3  | 7  | 5 | 4 | 6 | 3  | 7  | 6 | 6 | 181.64 |
| 4  | Less pressure during the blowing process | 7 | 4 | 6 | 5  | 6  | 3 | 6 | 5 | 3  | 4  | 7 | 6 | 137.5 |
| 5  | Odd Materials | 4 | 4 | 4 | 2  | 4  | 4 | 4 | 5 | 3  | 8  | 6 | 5 | 81.81 |

Based on data processed using FMEA, the results show that the main risk of the tea packaging process is a defective preform with an RPN value of 294 due to supplier errors so that handling can be carried out by handling the proper raw materials during the incoming process. Workers should pay more attention in detail to the quality of preforms received from suppliers. One of the determining factors for the success of the production process is raw material. In the case of procurement of raw materials, companies need to make efforts to search and select raw materials that will be used for the production process carefully [7]. Careful selection of raw materials is done so that companies use quality raw materials and avoid defects so they can produce quality products.

4. Conclusion

The quality control of primary tea packaging at the company is quite good, because the amount of damage that occurs is classified as very low. Based on analysis using SQC, the highest amount of
damage occurred in February of 3.95%. The most important thing to consider is the preform defect because it has the highest amount of damage of 48.7%. While the results of the risk analysis using FMEA show that defective preforms are the main risks that need to be controlled because they have an RPN of 294 due to supplier errors so that handling can be done by handling the proper raw materials during the incoming process. Careful selection of raw materials is done so that companies use quality raw materials and avoid defects so they can produce quality products.

References
[1] Setyamidjaja. 2000. Tea : Postharvest Cultivation and Processing. Yogyakarta. Kanisius [In Indonesian].
[2] Susetyarsi. 2012. Packaging In terms of packaging materials, packaging form and labeling on the packaging the effect on purchasing decisions on Mizone beverage products in the city of Semarang. Jurnal STIE Semarang. 4(3): 19-30 [In Indonesian].
[3] Bakhtiar, S., Suharto, T., and Ria, A.H. 2013. Quality Control Analysis Using Statistical Quality Control (SQC) Methods. Jurnal Teknik Industri Malikul-saleh. 2(1): 29-36 [In Indonesian].
[4] Iswanto, Adi. Dkk. (2013). Application of Taguchi Analysis and Failure Mode And Effect Analysis (FMEA) Method to Improve Product Quality at PT. XYZ. Medan : Universitas Sumatra Utara [In Indonesian].
[5] Yuliasih, N.K. (2014). Product Quality Control Analysis in 2013 Wana Sari Garment Company. E-journal Undiksha, Vol. 4, No. 1, pp. 1-12 [In Indonesian].
[6] Rosih, A.R., Mochamad, C., and Rahmi, Y. 2015. Operational Risk Analysis in the Logistics Department Using the FMEA Method. Rekayasa dan Manajemen Sistem Industri. 3(3): 580-591 [In Indonesian].
[7] Sentosa, E. 2017. The Effect of Quality of Raw Materials, Production Processes and Labor Quality on Product Quality at PT. Delta Surya Energi in Bekasi. Jurnal Ilmiah Ilmu Manajemen. 13(2): 62-71 [In Indonesian].