Implementation of Statistical Quality Control to Reduce Defects in Mabell Nugget Products (Case Study at PT. Petra Sejahtera Abadi)

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Abstract. Food and beverage industry is one of the five priority industrial sectors in the implementation of Industry 4.0 program. According to data from the ministry of industry throughout 2018, the food and beverage industry is able to grow by 7.91 percent or exceed national economic growth at 5.17 percent. PT. Petra Sejahtera Abadi is a company engaged in producing processed foods made from chicken and beef with freezing processes such as; sausage, smoke beef, spicy chick, spicy wings, nugget, rollade, and cornade beef. Data on the number of defects per year of nugget products from PT. Petra Sejahtera Abadi for the period of 2015 were 23,453 disabled, in 2016 as many as 21,876 disabled, in 2017 as many as 20,987 disabled. Based on the description above, the goal to be achieved in this study is to determine the Statistical Quality Control (SQC) method with control chart techniques and cause and effect diagrams applied by the company in controlling quality to minimize failed products. The results of the SQC implementation contained data that was out of control. For those out of the upper control limit, the 4th period in August 2018 and the 6th period in October 2018 are Out of the Upper Control Line (UCL). The most influential factor in the occurrence of product defects is the machine and material factors that must be immediately corrected.

1. Introduction
Food and beverage industry is one of the five priority industrial sectors in the implementation of Industry 4.0 program. The program is implemented with a legal umbrella Government Regulation (PP) Number 45 of 2019 [1]. According to data from the ministry of industry throughout 2018, the food and beverage industry is able to grow by 7.91 percent or exceed national economic growth at 5.17 percent [2], [3]. To keep the growth of this sector high, according to the Minister of Industry, he continues to encourage national food and beverage industry players to take advantage of the potential of the domestic market. "Indonesia, with a population of 258.7 million people, is a very promising market share. In addition, the national food and beverage industry is increasingly competitive because the numbers are quite large. Not only includes large scale companies, but also has reached at the district level for small and medium industrial classes (IKM). "In fact, most of them have already gone international. PT. Petra Sejahtera Abadi is a company engaged in producing processed foods made from chicken and beef with freezing processes such as: sausage, smoke beef, spicy chick, spicy wings, nugget, rollade, and cornade beef. Now the nuggets product is one of the superior products enjoyed by many consumers. The company strives to minimize defective products in order to meet customer demand. Quality control is one of the activities that is very closely related to the production process, where quality control is a system of verification and maintenance / maintenance of a level / degree of product quality or process
desired by careful planning, use of appropriate equipment, continuous inspection continuously, and corrective actions when needed [4]. For this reason, there is a need for quality control using the Statistical Quality Control (SQC) method so that the production results obtained experience a few products that fail. Statistical Quality Control (SQC) “Is a system developed to maintain uniform standards of quality of production, at a minimum cost level and is an aid to achieving efficiency” [5] [6]. Data on the number of defects per year of nugget products from PT. Petra Sejahtera Abadi for the period of 2015 were 23,453 disabled, in 2016 as many as 21,876 disabled, in 2017 as many as 20,987 disabled. Based on the description above, the goal to be achieved in this study is to determine the Statistical Quality Control (SQC) method with control chart techniques and cause and effect diagrams applied by the company in controlling quality to minimize defect products.

2. Method and Materials

2.1. Statistical Quality Control
Statistics Quality Control (SQC) or quality control statistics are problem solving techniques that are used to monitor, control, analyze, manage and improve products and processes using statistical methods. SQC is often referred to as Statistical Process Control (SPC). SQC and SPC are indeed two interchangeable terms, which if done together the user will see an overview of the performance of current and future processes [7]. Statistical Quality Control (SQC) has seven (7) main statistical tools that can be used as tools to control quality [8] [9], among others, that is: Check Sheet, histogram, control chart, pareto chart, fishbone diagram, scatter diagrams, and Design of Experiment (DOE).

2.2. Control Chart
Control Chart is a tool that graphically is used to monitor and evaluate activities or processes that are in quality control statistically, so as to solve problems and produce quality improvements [10]. The control chart shows changes in data from time to time, but does not indicate the cause of irregularities even though the storage will be visible on the control map. Several types of attribute control maps, viz [11]:
1. Control chart p, that is control chart for the rejected part because it is not according to specifications;
2. Control chart np, which is a control chart for the number of items that are not appropriate;
3. Control chart c, that is control chart for the number of nonconformities;
4. Control chart u, that is control chart for the number of discrepancies per unit.

2.3 Fishbone Diagram
Fishbone diagram is used to categorize various potential causes of a problem or subject matter in a way that is easy to understand and neat. Also this tool helps us in analyzing what really happens in the process. Namely by breaking down the process into a number of categories related to the process, including humans, materials, machines, procedures, policies and so on [12] [13]
2.4 Pareto Diagram
Pareto diagrams are bar charts and line graphs that illustrate the comparison of each data type to the whole. The function of the Pareto diagram is to identify the main problems for quality improvement from the largest to the smallest. In the Pareto diagram, the 80/20 rule applies, which means that 20% of the types of disabilities can cause 80% of process failures [14].

3. Results and Discussion
3.1 Description Data
To find out Critical to Quality (CTQ) of the types of defects can be seen in Table 1 [15] [16] [17] [18] [19] [20]

| Number | Month       | Production Amount (n) | Types of Nugget Defects | Total Defect / Month |
|--------|-------------|-----------------------|-------------------------|----------------------|
|        |             |                       | Form | Taste | Texture | Other |                     |
| 1      | June-18     | 17653                 | 769  | 525   | 458     | 593   | 2345                 |
| 2      | July-18     | 13450                 | 865  | 341   | 459     | 225   | 1890                 |
| 3      | August-18   | 17350                 | 873  | 765   | 543     | 161   | 2342                 |
| 4      | September-18| 16500                 | 939  | 340   | 398     | 234   | 1911                 |
| 5      | October-18  | 18200                 | 771  | 320   | 330     | 341   | 1762                 |
| 6      | November-18 | 16460                 | 954  | 657   | 188     | 582   | 2381                 |
| 7      | December-18 | 15320                 | 760  | 182   | 349     | 316   | 1607                 |
| 8      | January-19  | 14560                 | 789  | 436   | 142     | 297   | 1664                 |
| 9      | February-19 | 11456                 | 734  | 260   | 198     | 322   | 1514                 |
| 10     | March-19    | 14768                 | 765  | 333   | 231     | 202   | 1531                 |
| 11     | April-19    | 10987                 | 765  | 231   | 165     | 93    | 1254                 |
| 12     | May-19      | 13458                 | 876  | 167   | 143     | 161   | 1347                 |

| Amount    | 180162 | 9860 | 4557 | 3604 | 3527 | 21548 |
| Average   | 13424.8 | 821,6667 | 379,75 | 300,333 | 293,9167 | 1795,67 |

Table 1 shows that the amount of production made by PT. Petra Sejahtera Abadi is not the same every month. The average production per month is 13,424.8 with a total annual production of 180,162. The number of defects after being sorted according to the largest to the smallest percentage to find out Critical To Quality that still must be met by the company for the quality there are 4 critical and can be seen in Table 2 and can be illustrated in the Pareto diagram as shown in Figure 1.
Table 2 Defect Critical Order Produced by PT. Petra Sejahtera Abadi (June 2018-May 2019)

| Critical Defects | Number of Defects | Defect (%) | Cumulative (%) |
|------------------|-------------------|------------|----------------|
| Form             | 9860              | 45.76      | 45.76          |
| Taste            | 4557              | 21.15      | 66.91          |
| Texture          | 3604              | 16.73      | 83.63          |
| Other            | 3527              | 16.37      | 100.00         |
| Amount           | 21548             | 100        |                |

The most dominant type of disability that often occurs in Nugget products is a deformity of 45.76%. Statistical calculations are performed to determine the quality control that exists in the company is still within the control limits or not by statistical analysis of control p. The calculation of control p type of mabell nugget defects can be seen in Table 3.

Table 3 Proportion of Nugget Defects Per Month

| Number | Month       | Production Amount (n) | Number of Form Defect | Number of Defect (%) |
|--------|-------------|-----------------------|-----------------------|----------------------|
| 1      | June-18     | 17653                 | 769                   | 4.36%                |
| 2      | July-18     | 13450                 | 865                   | 6.43%                |
| 3      | August-18   | 17350                 | 873                   | 5.03%                |
| 4      | September-18| 16500                 | 939                   | 5.69%                |
| 5      | October-18  | 18200                 | 771                   | 4.24%                |
| 6      | November-18 | 16460                 | 954                   | 5.80%                |
| 7      | December-18 | 15320                 | 760                   | 4.96%                |
From Table 4, the calculation of the proportion of nugget defects per month is as follows:

a. **Calculation of the 1st month**

Calculates the value of the "Form" nugget defect proportion

\[ np = 769 \]
\[ n = 17653 \]
\[ P = \frac{np}{n} = \frac{769}{17653} = 0.043562 \]

b. **Calculation of the 2nd to 12th months as in the steps above**

c. **Below is the calculation of the central line control limit (p), LCL and UCL can be seen in Table 5**

**Table 5 Calculation of Controller Limits (p), LCL and UCL**

| Number | Month         | Product Amount | Number of Defects | Average   | Proportion (p) | UCL          | LCL          |
|--------|---------------|----------------|-------------------|-----------|----------------|--------------|--------------|
| 1      | June-18       | 17653          | 769               | 821,6666667 | 0.043562001   | 929.9894     | 633.0106     |
| 2      | July-18       | 13450          | 865               | 821,6666667 | 0.064312268   | 929.9894     | 633.0106     |
| 3      | August-18     | 17350          | 873               | 821,6666667 | 0.050317003   | 929.9894     | 633.0106     |
| 4      | Sep-18        | 16500          | 939               | 821,6666667 | 0.056909091   | 929.9894     | 633.0106     |
| 5      | October-18    | 18200          | 771               | 821,6666667 | 0.0423623673  | 929.9894     | 633.0106     |
| 6      | Nov-18        | 16460          | 954               | 821,6666667 | 0.057958688   | 929.9894     | 633.0106     |
| 7      | December-18   | 15320          | 760               | 821,6666667 | 0.049608355   | 929.9894     | 633.0106     |
| 8      | January-19    | 14560          | 789               | 821,6666667 | 0.05418956    | 929.9894     | 633.0106     |
| 9      | February-19   | 11456          | 734               | 821,6666667 | 0.064071229   | 929.9894     | 633.0106     |
| 10     | March-19      | 14768          | 765               | 821,6666667 | 0.051801192   | 929.9894     | 633.0106     |
From Table 5 above, the calculation of the central line controller (p), LCL, and UCL, calculation of the 1st month

1. Calculate the center line control value (p)
\[
P = \frac{\sum np}{\sum n} = \frac{46897}{12} = 821,667
\]

2. Lower Control Chart (LCL = Lower Control Point)
\[
LCL = \frac{P - 3\sqrt{P(1-P)}}{n}
\]
\[
LCL = \frac{821.667 - 3\sqrt{821.667(1 - 821.667)}}{12}
\]
\[
LCL = 633,0106
\]

3. Upper Control Chart (UCL = Upper Control Point)
\[
UCL = \frac{P + 3\sqrt{P(1-P)}}{n}
\]
\[
UCL = \frac{821.667 + 3\sqrt{821.667(1 - 821.667)}}{12}
\]
\[
UCL = 929,9894
\]

Based on Table 5, it can be made a map of control - P Form nugget defects that can be seen in Figure 6
Based on Figure 2 of the control map above, there is data that is outside the control limits. For those out of the upper control limit, the 4th period in August 2018 and the 6th period in October 2018 are out of control (UCL).

3.2 Fishbone Diagram
To make it easier to find out the cause and effect of form nugget defects, a fishbone diagram is used. This diagram is also called a fishbone diagram which is useful for determining the main factors (causes) that affect the quality (effect) caused by factors causing them including material, machine/tool, method, human and environmental factors. To determine the main factors that influence the emergence of product defects in making fishbone diagrams, namely by direct interviews with Managers and Supervisors from the Quality Control Department, Technical Department, Production Department as well as giving questions about the causes of form nugget defects in mabell products at PT. Petra Sejahtera Abadi. The following is the shape of the fishbone diagram which can be seen from Figure 3.

Figure 3 Fishbone Diagram
Based on Figure 3, the results of the analysis for the defective mabell product shape defect using a fishbone diagram (cause and effect) with 5 factors, namely material, human, method, machine and environment. The most influential factor in the occurrence of product defects is the machine and material factors that must be immediately taken corrective actions such as:
1. High Breading Conveyer and Deep Frying Conveyer are equalized;
2. Adjust the speed of the deep frying conveyer so that the product does not stack and stick;
3. Make the standardization of the dough so it is not mushy.

4. Conclusion
Based on the results and discussion, the following conclusions can be obtained:
1. There is a form nugget data defect that is out of control. For those out of the upper control limit, the 4th period in August 2018 and the 6th period in October 2018 are out of the upper control (UCL);
2. From the results of the fishbone diagram obtained corrective actions to reduce the number of defects that is by way of:
   a. High Breading Conveyer and Deep Frying Conveyer are equalized;
   b. Adjust the speed of the deep frying conveyer so that the product does not stack and stick;
   c. Make the standardization of the dough so it is not mushy.

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