Analysis of SS Tempe production quality control with the six sigma method at Sirajussa’adah Islamic Boarding School Limo Depok

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ABSTRACT

Quality is a factor to increase the competitiveness of a product. By increasing quality, the production costs will be reduced, thus it will eventually reduce waste. The failure of a product can be caused by the availability of raw materials, machines, equipment, human resources, and environmental factors during the production process. Quality control is a method used to keep the product needed by the market to be within controlled limits. This study aims to determine the quality of Tempe SS products at the Sirajussa’adah Islamic Boarding School in Limo Depok. It is carried out to see whether the quality is still within control limits or not by using the Six Sigma method with several stages of DMAIC (Define, Measure, Analyze, Improve and Control) implementation. In this research, calculations are carried out using the checksheet, flow chart, histogram, Pareto Chart, control chart, scatter diagram and fishbone diagram methods of production. Based on the results, it can be concluded that for 25 times the study, it is obtained the value of the center line (CL) of 0.0036, the value of the upper control limit (UCL) of 0.0050, and the value of the lower control limit (LCL) of 0. It is also found that there are a number of variations in the process that are outside the control limit (out of control) and within the control limit (in control) in the production process of Tempe SS at the Sirajussa’adah Islamic Boarding School in Limo Depok. However, this is still inadequate for the fermentation process infrastructure, equipment for packaging is still manual and environmental factors determine the cause of the number of defective products.

Introduction

Quality is one of the factors used to measure and increase the competitiveness of a product. Improved quality will make the costs incurred for production to be small and able to reduce waste. Products may fail due to several causes, such as raw materials, labor, production processes, equipment, machines, work environment. To maintain the quality of the products produced and meet market demand, it is necessary to control the quality of the activities and processes carried out. To determine the quality of the products produced in this study, the Six Sigma method was used. Six Sigma is a process management technique that is focused to improve the quality management technology that can help business to improve their current processes, products, or services (Siddiqui et al., 2016; Ullah et al., 2017).

This study focuses on the tempeh production, called ‘Tempe SS’, in Sirajussa’adah Islamic boarding school, which is located in Limo, Depok, West Java. Sirajussa’adah is an Islamic boarding school and a private Islamic institution. It was initiated since 2007 by Mr. KH. Abdurrahman using the method of Islamic boarding school salafyiah education and formal education. In the production of tempeh, continuous improvement is being made in order to overcome the obstacles and problems that often occur with the aim that the students and alumni of the students become prosperous and independent. Tempe SS is produced by the students and alumni as a form of education, so that they are not only knowledgeable but also have a strong spirit of independence. It is also expected to help them answer every challenge in the midst of society, especially in the field of economic development in order to create independent students and Islamic boarding schools that can empower.

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Tempe SS is tempeh that is in demand by residents around the boarding school. The distribution of the tempeh is carried out by local residents such as traditional stalls from house to house, because the demand for tempe is very high. The demand for the product is increasing because it is known that the tempeh is hygienic, with the need for soybeans increasing by an average of 2 (two) quintals per day. The Tempe SS production process has a different process from other tempeh production processes, namely: washing for 6 (six) times until it smells clean, then peeling and boiling for 2 (two) times so that it lasts longer, tastes more delicious and is hygienic. However, in the production process, there are still defective Tempe SS, which is why they continue to carry out quality control to minimize the damage that still occurs. Defective products will make tempe entrepreneurs lose, because with defective products, sales will decrease while the production costs will increase. To reduce defective products, it is necessary to have control stages carried out with the aim of evaluating performance and for further improvement.

Currently, commercial competition is also carried out by prioritizing product quality. Therefore, it will cause the company's productivity level to increase, while lowering the product prices and quality (Idris, 2019). This study proposes Six Sigma method as an effort to increase the product quality management, because it can reduce the cost and defect while also enhance productivity, market share growth, and production or service development (Pandey, 2007). Therefore, based on the problems that have been identified, namely whether the defective product is still within controlled limits or not, the authors are interested to conduct research on quality control in the production of Tempe SS by using the Six Sigma method through the DMAIC (Define, Measure, Analyze, Improve and Control) stage at Sirajussa'adah Islamic Boarding School Limo Depok.

This paper is organized into a several parts. First, in the introduction part, the author explains the research background which underlies the reason why this study is carried out. Following the introduction part, a second part is a literature review with theoretical and empirical studies that shed a light on linkage between theory and practice regarding the use of Six Sigma as quality control for tempeh product. The third part introduces the background information on research and methodology. After analysis and findings of the study, authors provide discussions and implications. Finally, this paper concludes with key points, recommendations, future research directions and limitations.

**Literature Review**

**Theoretical and Conceptual Background**

**Quality**

According to Prawirosentono (2007), quality is the physical state of the product, the function of the product, and the nature of a product that can satisfy consumer tastes and can meet consumer needs by comparing the value of money spent to have the product. Purnomo (2007) added that quality itself has the meaning of controlling activities carried out to measure product quality characteristics, make comparisons with specifications or requirements, and provide results to take actions in accordance with established standards if there are differences in appearance.

A number of scholars have provided different notion of quality. Juran & Godfrey (1999) defined quality as "the purpose or benefit of a product". Quality is also defined as the accuracy of a product in meeting needs which include availability, delivery, reliability, maintainability, and cost effectiveness (Crosby, 1979). Quality has the aim of being able to meet current and future consumer needs and expectations (Deming, 1982; Goetsch & Davis, 1995), which comes from the products and services that can provide conformity to consumer needs and consumer expectations in their use (Feigenbaum, 1991).

Scherkenbach (1991) suggested that quality can be determined by the customer, where customers have the products and services they want and these products and services are in accordance with customer needs and achieve expectations at a certain price level that gives an assessment of the product. Quality is something that is produced from products and services which have different values for different people and this also depends on time and place, can also be adjusted to the purpose (Elliot, 1993).

**Quality Control**

Assauri (2014) defined control as "an activity that guarantees that the activities and production operations carried out are in accordance with what is expected, if there are deviations that occur, the deviations can be corrected and things that are hoped for can be achieved by the perpetrators." According to Montgomery (2015), quality control is an activity related to engineering and management, where the activity is measured by product quality characteristics, comparing with specifications or statements.

The aims and objectives of quality control are: (a) quality standards of goods produced are as expected; (b) minimize inspection costs to a very small extent; (c) minimize the cost of the machine and the process with the production quality to be very small; and (d) minimize the cost of production as small as possible (Assauri, 2014). In addition, Reksohadiprojo and Sudarmo (1985) mentioned that quality control has the aim of improving product quality, maintaining product quality, and minimizing damaged materials. Quality control is also aimed to increase consumer decisions, minimizing cost as small as possible, and make sure that the selection is in accordance with the targeted time (Ahyari, 1985).

According to Gaspersz (2001), quality management can be defined as all activities of the overall management function that determine quality policies, objectives, and responsibilities and implement them through quality management tools, such as quality planning,
quality control, quality assurance, and quality improvement. Lakman et al. (2021) emphasized that quality control is an activity to obtain finished goods which quality is in accordance with the desired standard or an inspection system. The final purpose is that through careful inspection of raw materials, materials in the process of semi-finished goods, as well as finished goods, an analysis can be carried out to determine the actions that must be taken in the production process to achieve and maintain a predetermined product. Quality control is responsible for establishing and maintaining the necessary control of quality for material.

Six Sigma Method

Six Sigma is a technologically advanced method that is used to improve or develop a product. Six Sigma is a process management technique that is focused on improving the quality management methodology that can help businesses improve their current processes, products, or services (Siddiqui et al., 2016) by minimizing and eliminating defects (Ullah et al., 2017). The purpose of Six Sigma is to provide satisfaction to customer needs that is close to perfection. Six Sigma can also be understood as an effort to change corporate culture to achieve customer satisfaction, better profits and competition.

Six Sigma has been considered as a complete and flexible system for maximizing, achieving, and supporting business processes which main objective is to understand what will satisfy customer needs using facts, calculated statistical data and analysis, as well as continuously observed configurations, making improvements and reviewing iterations of business processes. Six Sigma provide different benefits to each company that implements it, and it depends on the business run by the company. To overcome, identify and analyze various existing products, the Six Sigma method can be used with the DMAIC (Design, Measure, Analyze, Improve, and Control) stages that must be passed, starting from define to control (Tannady, 2015; Koziolek & Derlukiewicz, 2012; Zhu et al., 2013; Ullah et al., 2017; Qayyum et al., 2021).

The DMAIC method is designed for optimizing existing processes or products that do not meet customers’ needs or fail to perform as expected (Sokovic et al., 2010). The method consists of 5 main stages, which are explained as follows:

i. Define. In this phase, the process improvement objectives that are consistent with the demands or needs, customers and business strategy is defined (Gasperz & Fontana, 2017). The define phase is the initial identification phase, where it is necessary to recognize the effects of the problems that arise (Tannady, 2015).

ii. Measure. In this phase, the current process performance is compared to the target (Gasperz & Fontana, 2017). The parameter used in measuring the capability of the ongoing process is the quality of the product as measured through the existing process (Tannady, 2015).

iii. Analyze. This phase consists of finding out the dominant factors that need to be controlled from the interrelated causes and effects (Gasperz & Fontana, 2017). The analysis stage of the DMAIC function is to provide solutions to priorities that are carried out to overcome the causes of problems that arise, uncover the impact of process and final product defects on customers, the causes of failure at the beginning of the causes of the problem, and provide solutions (Tannady, 2015).

iv. Improve. In this phase, the process is improved by eliminating the root causes of defects (Tannady, 2015; Qayyum et al., 2021) through inventive solution. It is carried out to optimize the process through Design of Experiments (DOE) so that the process can be known and controlled so that maximum conditions can be achieved (Gasperz & Fontana, 2017).

v. Control. In the control phase, the new process is controlled to avoid falling into old habits and guaranteeing that it stays on track (Qayyum et al., 2021). Regular and continuous control has the purpose of to increase process capacity to achieve Six Sigma goals (Gasperz & Fontana, 2017). This phase functions as supervision or activities related to supervision and monitoring that have been designed and programmed for product improvement plans, this is the same as the improvement process that is maintained in this phase (Tannady, 2015).

Quality Control for Tempeh Product

Damanik et al. (2020) carried out a study on UD. Habib, which is a tempeh company that uses soybean as a raw material. However, the condition in the company indicates that there is still ineffective production processes as well as defects in the tempeh product, which make the quality of tempeh become unexpected. Therefore, Damanik et al. (2020) used Lean Six Sigma method to define the problem and provide the solutions. Based on the results of the study, it is found several problems that cause the defects to occur: bitter taste of tempeh that comes from the raw material, unclean washing process, insufficient cooking time, as well as poor fermentation and milling methods for soybeans. For defects in tempeh consumed by animals, it is caused by an unhealthy factory environment and the many cavities around the factory as well as production waste left by soybeans after being washed and fermented.

Rahayu (2019) also carried out a study on Tempeh Semanan SMEs by applying the DMAIC method in Six Sigma. After analyzing the data, it was found that there are three types of defects that occur, namely sour taste, imperfect product (tempeh), and products that are being eaten by animals. Furthermore, it is also found that there are data that are outside the control limits caused by the occurrence of defects that occur in each tempe craftsmen's house. The results show the value of UCL 0.18 and LCL 0. After calculating the control chart p, the Pareto map of the three defects shows the percentage of each defect: imperfect product (tempeh) (30.1%), eaten by animals (20.5%), and sour taste (49.4%).
Furthermore, Hasanah et al. (2019) conducted a study of quality control in tempeh production in Somber Balikpapan Home Industry. The research was conducted through field research to see the production process, while the data collection is done through interviews. The data obtained is then analyzed using statistical method and quality control. The results indicate that the product failure rate is almost 0% or zero due to the strict quality control adopted in the production method.

In addition, Umami (2020) analyzed the quality control of tempeh products in Morowali Regency, Central Sulawesi. The study is carried out using Seven Tools namely scatter diagrams, control charts, cause and effect diagrams, Pareto diagrams, histograms, stratification and check sheets. This research was produced based on 20 days of research on tempeh products, namely 1201 which resulted in an average defect of 35.7. Then 29% had foreign bodies, 17% were eaten by animals, 39% had ripeness and 16% had color defects. The level of maturity is the most dominant thing in the level of defect of tempe products with temperature factor. In reducing these defects, there are several solutions, namely industrial cleanliness and more maintained equipment, rearrangement of industrial space, and early planning so that the tempeh processing process can be more regularly scheduled and can be well controlled.

Finally, Idris (2019) conducted 20 observations with the calculation of the control map for quality control in tempeh products. From the results, it can be concluded that the value of the center line (central line) is 3, the value of the upper control limit (UCL) is 5.6, and the value of the lower control limit (LCL) is 0.32. It is explained that there is no process variation that is outside the control limit (out of control), in other words it is still within the control limit (in control). The results also indicate that the production environment conditions have an effect on producing the number of defective tempeh products.

Research and Methodology

This research was conducted at the Sirajussa'adah Islamic Boarding School in Limo District, Depok, West Java, Indonesia. The study is conducted by taking samples that were tested 25 times on the data of the Tempe SS production process in June 2021. In this study, the data collection is obtained through observations and interview with students who produce Tempe SS. From the observation and interviews, it is obtained the data about the use of raw materials, marketing methods, and the number of defective products from each production.

The data is then analyzed using the Six Sigma method with DMAIC stages (defining, measuring, analyzing, improving, controlling). In stage 1, the authors define the use of CTQ to determine the most dominant error in tempe, the SIPOC diagram, where this phase provides a complete picture of the whole process. In stage 2, the authors carry out measurement to calculate the DPMO of the product, the Six Sigma value of the tempeh product to determine the product's sigma level, and calculates the control table using pchart. In stage 3, the authors conduct an analysis based on Ishikawa diagram (fish bone), which aims to identify the causes of product defects that occur. In stage 4, the process is enhanced with FMEA to maximize quality improvement. Finally, in stage 5, control is carried out to assure that the process stays on track.

Analysis and Findings

This research was conducted at the Sirajussa'adah Islamic Boarding School in Limo District, Depok, West Java, Indonesia. In order to equip the students' abilities for independent businesses, the Sirajussa'adah Islamic Boarding School has built pesantren business units which are handled and worked on by the students; school. The business units include: Tempe SS, pure honey, and Sirajussa'adah mineral water.

The production process of making tempeh begins with soaking soybeans for 12 hours, then put in the process of peeling with a machine. After that, the process continues by separating the dregs from soybeans, washing them for six times then boiling soybeans for two times. After the soybeans are cooled, it is given yeast with an appropriate dose of 1:3, stirred until evenly distributed, then packaged and fermented manually so that hygienic Tempe SS will be produced (stays fresh and lasts a long time). The total production of Tempe SS during the month of June produced 17,066 units with 62 units damaged for 25 times of data collection.

After obtaining the required data, quality control is carried out using the Six Sigma method with the DMAIC (Define-Measure-Analyze-Improve-Control) stages, as follows:

Define

In the define stage, the description of the CTQ (Critical to Quality) related to the fulfillment of quality standards and the level of quality that must be maintained is determined and defined. For example, the defects that occur in Tempe SS are caused by fermenting tempeh eaten by animals (rats), as it can occur because the facilities and infrastructure of the room used are still open, thus this defect occur frequently.
Measure

In this stage, the p control map was calculated using a sample for 25 days of research to determine UCL & LCL. The tool that is used and shows graphic data is then used to evaluate or monitor the activities of a process that is still in quality control or not statistically, therefore it can solve existing problems and improve quality.

Check Sheet

From the results of data collection, it is known that the number of Tempe SS production is 17,066 units with 62 units of damage for 25 times of data collection. The data collection of research results is presented in the check sheet table as follows:

<table>
<thead>
<tr>
<th>No</th>
<th>Production Quantity</th>
<th>Number of Defective Products</th>
<th>Damage Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>651</td>
<td>3</td>
<td>0.0046</td>
</tr>
<tr>
<td>2</td>
<td>610</td>
<td>2</td>
<td>0.0033</td>
</tr>
<tr>
<td>3</td>
<td>710</td>
<td>1</td>
<td>0.0014</td>
</tr>
<tr>
<td>4</td>
<td>670</td>
<td>4</td>
<td>0.0060</td>
</tr>
<tr>
<td>5</td>
<td>640</td>
<td>1</td>
<td>0.0016</td>
</tr>
<tr>
<td>6</td>
<td>550</td>
<td>2</td>
<td>0.0036</td>
</tr>
<tr>
<td>7</td>
<td>811</td>
<td>3</td>
<td>0.0037</td>
</tr>
<tr>
<td>8</td>
<td>712</td>
<td>5</td>
<td>0.0070</td>
</tr>
<tr>
<td>9</td>
<td>615</td>
<td>1</td>
<td>0.0016</td>
</tr>
<tr>
<td>10</td>
<td>660</td>
<td>2</td>
<td>0.0030</td>
</tr>
<tr>
<td>11</td>
<td>570</td>
<td>1</td>
<td>0.0018</td>
</tr>
<tr>
<td>12</td>
<td>718</td>
<td>4</td>
<td>0.0056</td>
</tr>
<tr>
<td>13</td>
<td>821</td>
<td>1</td>
<td>0.0012</td>
</tr>
<tr>
<td>14</td>
<td>653</td>
<td>2</td>
<td>0.0031</td>
</tr>
<tr>
<td>15</td>
<td>714</td>
<td>3</td>
<td>0.0042</td>
</tr>
<tr>
<td>16</td>
<td>710</td>
<td>1</td>
<td>0.0014</td>
</tr>
<tr>
<td>17</td>
<td>670</td>
<td>4</td>
<td>0.0060</td>
</tr>
<tr>
<td>18</td>
<td>715</td>
<td>2</td>
<td>0.0028</td>
</tr>
<tr>
<td>19</td>
<td>813</td>
<td>3</td>
<td>0.0037</td>
</tr>
<tr>
<td>20</td>
<td>610</td>
<td>1</td>
<td>0.0016</td>
</tr>
<tr>
<td>21</td>
<td>780</td>
<td>7</td>
<td>0.0090</td>
</tr>
<tr>
<td>22</td>
<td>591</td>
<td>2</td>
<td>0.0017</td>
</tr>
<tr>
<td>23</td>
<td>712</td>
<td>2</td>
<td>0.0028</td>
</tr>
<tr>
<td>24</td>
<td>645</td>
<td>4</td>
<td>0.0062</td>
</tr>
<tr>
<td>25</td>
<td>715</td>
<td>2</td>
<td>0.0028</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17,066</strong></td>
<td><strong>62</strong></td>
<td><strong>0.0897</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>683</strong></td>
<td><strong>3</strong></td>
<td><strong>0.0036</strong></td>
</tr>
</tbody>
</table>

Source: Processed Data (Author, 2022)

Based on the data in Table 1 above, it can be explained that during June 2021, within 25 days of production, the total production of Tempe SS was 17,066 units with a total of 62 units of damage. With an average production of 683 units of Tempe SS and an average of 3 units of damage, the defects in the production of Tempe SS were caused by animals (rats) due to inadequate facilities and infrastructure (in open spaces) and environmental factors. Based on the results of the check sheet, a histogram is then created. This histogram is useful to make it easier to read the defective product process and find out whether the product is up to standard or not. The histogram of the number of productions and the number of defective products of tempe SS are as follows:

![Figure 1: Histogram of Total Production and Total Defects of Tempe SS](image-url)
Control Charts (Control Charts)
Control Limits For P. Charts
Supervision using the Control Chart method called the P-Chart.
P-Chart is a section for the proportion or damaged part that occurs. The P-Chart method has the following control limits: (Gran and Leavenworth, 1990):
- UCL = P + 3 Sp
- LCL = P - 3 Sp

This limit in the Quality Control of its use is as follows according to Reksohadiprojo and Indriyo, (1996):

\[
P = \frac{x}{n} = \frac{62}{17.066} = 0.0036
\]

Information:
P = Average damage (mean)
x = Number of damaged items
n = Number of items observed to find the standard deviation of damage:

\[
S_p = \sqrt{\frac{P(1-P)}{n}}
\]

Sp = Standard Deviation

Product control limits are:
- Mean damage ± three standard deviations
- P ± 3 Sp

Upper limit (BKA) that can still be tolerated or Upper Control Limit = P+3Sp= 0.0050
Lower limit (BKB) that can still be tolerated or Lower Control Limit = P - 3 Sp = 0

If the Upper Control Limit is more than 100 percent, then it is stated as 100 percent, while the Lower Control Limit is less than zero, then the lower limit is considered zero. The following diagram shows the Control Chart. From the results of the calculation of the data from the tempe SS research that has been collected, the values of CL, UCL and LCL are shown in the following table:

**Table 2: Calculation of SS Tempe Control Limit in June 2021**

<table>
<thead>
<tr>
<th>No</th>
<th>Production Quantity</th>
<th>Defective Products</th>
<th>P</th>
<th>CL</th>
<th>UCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>651</td>
<td>3</td>
<td>0.0046</td>
<td>0.036</td>
<td>0.0117</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>610</td>
<td>2</td>
<td>0.0033</td>
<td>0.036</td>
<td>0.0106</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>710</td>
<td>1</td>
<td>0.0014</td>
<td>0.036</td>
<td>0.0078</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>670</td>
<td>4</td>
<td>0.0060</td>
<td>0.036</td>
<td>0.0126</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>640</td>
<td>1</td>
<td>0.0016</td>
<td>0.036</td>
<td>0.0083</td>
<td>0</td>
</tr>
<tr>
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<td>550</td>
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<td>0.0036</td>
<td>0.036</td>
<td>0.0112</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>811</td>
<td>3</td>
<td>0.0037</td>
<td>0.036</td>
<td>0.0104</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>712</td>
<td>5</td>
<td>0.0070</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>0.0101</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
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<td>3</td>
<td>0.0042</td>
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<td>0.0109</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
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<td>0.0014</td>
<td>0.036</td>
<td>0.0078</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>670</td>
<td>4</td>
<td>0.0060</td>
<td>0.036</td>
<td>0.0126</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>715</td>
<td>2</td>
<td>0.0028</td>
<td>0.036</td>
<td>0.0095</td>
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<td>0.0028</td>
<td>0.036</td>
<td>0.0095</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Processed Data (Author, 2022)
Based on the data in table 2 (two) above, the results of the calculation of the control chart for the proportion of damage, center line (CL), upper control limit (UCL), and lower control limit (LCL) obtained from the results of research on Tempe SS production for 25 days are then described in control chart diagram of the proportion of damage to tempe SS in June 2021. The control chart diagram is as follows:

**Figure 2:** Diagram of SS Tempe Damage Proportion Control Map (June 2021)

Based on Figure 2 above on the control chart p, it can be seen that the results show that not all of products are within the control limits set by the company, the data shows that some damage is outside the control limits. In the results numbers 4, 8, 12, 17, 21 and 24, it can be interpreted that the production process carried out in the Tempe SS business is not yet under control. Therefore, it can be concluded that there are still deviations that occur and quality control in the SS tempeh business still requires improvement.

After calculating the research results that are outside the control limits, a recalculation is carried out by removing the research data numbers 4, 8, 12, 17, 21 and 24 that do not meet the requirements. Based on this, the calculation results obtained are illustrated in the revised control chart diagram as follows:

**Figure 3:** Control Chart p Revision

From Figure 3 above, it shows that there is no damage value that is outside the control limits, both the upper and lower control limits, with the UCL value being 0.0066 and the LCL being 0.

**Analyze**

In this stage, an analysis is carried out to find out the dominant factors that affect the defects in Tempe SS. This stage is carried out using a Pareto diagram which functions to see the percentage of the factors causing defects that occur in tempeh to find which factor is more dominant. This chart shows the problem based on the number of occurrences.

From the results of the calculations in Table 1, it is found that the data obtained for tempe SS in June 2021 is as many as 62 production defects. Furthermore, the causes of defect identified are in the fermentation process, the facilities and infrastructure are still open, and the equipment used for packaging is still manual. The priority of quality control to improve the product quality must be done by considering the most dominant factors that cause production defects. Table 3 presents the types of defects and the percentage in the production process of Tempe SS.

**Table 3:** Types of Defects in SS Tempe Production (June 2021)

<table>
<thead>
<tr>
<th>No</th>
<th>Type of defect</th>
<th>Number of defects</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eaten by animals</td>
<td>54</td>
<td>87%</td>
</tr>
<tr>
<td>2</td>
<td>Packaging is not perfect</td>
<td>8</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>62</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Processed Data (Author, 2022)
Table 3. (three) above shows that the type of defect in Tempe SS due to being eaten by animals (rats) is 54 (87%), while due to imperfect packaging is as much as 8 (13%). The results of the calculation of the factors that cause the SS tempe defects is graphed into a Pareto diagram. The Pareto diagram images are as follows:

Figure 4: Pareto Chart

Based on Figure 4 (three) Pareto diagrams above, it can be seen that the results show that the most dominant types of defects that occur are being eaten by animals (rats) and manual packaging on Tempe SS. Therefore, optimizing quality control improvements must be prioritized because of this defective product.

Improve

Animals are one of the factors that make this tempeh production defective. From the observations, it was known that about 87% of defective products were eaten by animals. This is because the fermentation process is carried out in an open room. Furthermore, 13% of defective products were caused by imperfect manual packaging, and it cause the tempeh to have uneven form. However, these defects are not entirely blamed on the behavior of the animals that eat tempeh. The quality of human resources, work methods, as well as production tools and materials also affect the incident.

The next step is to create a fishbone diagram. This stage is carried out when the calculation and Pareto diagram has been finished. The fishbone diagram that explains the causes of defects in tempeh products is shown in Figure 5 below:

Figure 4: Fishbone Diagram

The factors that cause defects in tempeh products are machine and equipment, methods, materials, and also humans or workforce. From these causes, more details are explained as follows:
Machine and equipment

The use of machines or equipment in the production of tempe SS is carried out for packaging that is still done manually. Therefore, the packaging of the Tempe SS is not quite good. From the existing problems, there is a way to overcome them, namely to have a special tool for packaging.

Method

The method used in the tempeh packaging process is not good. As a result, the final product is not good as well. From these problems, there are ways to overcome them, namely:

i. Looking for packaging method development
ii. Updating the method used in regular manner to adjust to the condition

Materials

The materials used in the manufacture of soybean tempeh are unstable, because the supply is not always available. Therefore, the availability of materials is of poor quality. In addition, the additional materials used as a complement to the process of making tempeh do not go through the stages of inspection by the workers. As a result, since the main ingredients and the supporting materials are not good, the tempeh products have poor quality.

Countermeasures:

i. The materials used in making tempeh must be checked properly and must use materials with good quality.
ii. The additional materials used must be inspected so that the quality is maintained.

Human or workforce

Human or workforce is the most important factor of all existing indicators. This is because the quality of the product is very influential on the quality of the workforce. If the quality of the workforce is not good and they do not have enough experience, the resulting product will not be good enough. The quality of the workforce must be maintained and must be provided with supplies, so that the resulting product is in line with expectations. The way to overcome this is by providing socialization related to production activities. The production staff of Sirajussa'adah Islamic Boarding School is still concurrently carrying out the work of the sales distribution division as well, because the available workforce is still limited.

Control

This stage is the last stage performed on the DMAIC Six Sigma method. This stage has not been carried out by the production team in Sirajussa'adah Islamic Boarding School. The control stages can be done by carrying out several things:

i. Strict procedures must be carried out to control the steps involved in making Tempe SS. The most important steps to control are washing, curing, and fermentation.
ii. Every repair process carried out must be supervised.
iii. Training of workers must be carried out to improve the quality of the products.
iv. It is necessary to add additional sales distribution staff and marketing strategies in order to increase sales turnover of tempe SS Sirajussa'adah Islamic Boarding School.

Conclusions

Defects in the product are caused because the plastic used to wrap tempeh is eaten by animals (rats) until it has holes, so the defective product cannot be marketed to consumers. In addition, the tempeh in the plastic has not been completely finished due to uneven packaging. Other factors that cause defects in tempeh products are inadequate environmental conditions, poor quality of raw materials, bad packaging process, inadequate room for fermentation process.

The control stage carried out by the production team of Tempe SS at the Sirajussa’adah Islamic Boarding School is to find out the cause of the lack of quality of the tempeh produced. From this stage, it provides several solutions, namely providing an adequate fermentation room, buying an automatic machine for the fermentation process and packaging, and conducting training for workers.

Good training or guidance is held for existing workers and using machines in the process of fermentation and packaging as well as maintaining the cleanliness of the production area environment. The tempe production staff of Tempe SS at the Sirajussa’adah Islamic Boarding School is still carrying out the double duty of sales distribution, because the available workforce is still limited. Based on the conclusions of the results of this study, it provides several recommendations for the production staff of Tempe SS in Sirajussa’adah Islamic Boarding School:

i. It is necessary to improve skills in producing SS tempe which is carried out by the student staff, namely through training.
ii. It is necessary to arrange the layout of the facilities in the production process due to inadequate environmental factors.
iii. It is necessary to use machine tools that are not manual in every production process.
iv. It is necessary to improve the distribution and sales strategy of Tempe SS.
Acknowledgement

All authors have read and agreed to the published version of the manuscript.


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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

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