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APPLICATION OF SIX SIGMA METHOD TO REDUCE DEFECT RATE IN BREAD PRODUCTION

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ABSTRACT

This research discusses the application of the Six Sigma method with the DMAIC approach to reduce the defect rate of bread products at Fadillah Bakery. Through seven days of observation, 248 defective products were found from 2.100 samples with an average Defect Per Million Opportunities (DPMO) of 118.095,2 and asigma level of 2,19. The analysis showed that the factors causing product defects include human error (lack of training and accuracy), non-optimal work methods, and improper roasting machine settings. The proposed improvement measures include increased worker training, scheduling machine maintenance, and stricter supervision. The proposed improvement measures included increased worker training, scheduling machine maintenance, and stricter supervision. The results prove that the implementation of Six Sigma is effective in reducing defect rates, improving product quality, and production process efficiency. Continued implementation is expected to improve Fadillah Bakery's competitiveness and customer satisfaction of Fadillah Bakery.

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1. INTRODUCTION

The bread industry is one of the fastest growing food sectors in Indonesia, with demand continuing to increase along with changes in people's lifestyles that prioritize practicality. Bread is not only a daily food, but also a snack option that is widely consumed [1]. However, in the production process, the bakery industry often faces defect problems that can affect product quality and safety. These defects include various aspects, such as changes in texture, flavor, and appearance, which can affect consumer satisfaction [2].

The application of Six Sigma methods has proven effective in improving quality and efficiency in various industries, including the food sector [3]. Six Sigma is a data-driven approach that aims to reduce variation in processes and improve product quality by identifying and eliminating the root causes of problems. This method involves the use of statistical tools and analysis techniques that assist companies in understanding the production process and detecting potential defects [4].

Several previous studies have indicated the successful application of Six Sigma in the food industry, resulting in significant improvements in product quality. Such as research conducted at the Azhari Toast

Factory to analyze toast products using six sigma and kaizen methods. The results showed that the most dominant percentage of product defects were torn bread defects at 69% and toast defects at 31%. Proposed improvements include air measurement, improvements by providing a timer feature on the oven machine, the use of digital measuring instruments, rearranging the production area, and making symbols on the storage area as well as a schedule of working hours and breaks [5].

One of the main challenges in bread production is maintaining quality consistency. Variations in raw materials, production processes, and storage environments can cause significant defects [6]. Using a Six Sigma approach, bakery manufacturers can analyze production data and identify factors that cause defects. This step will not only improve product quality, but also reduce the costs associated with losses due to defects [7].

This journal aims to explore the application of the Six Sigma method in reducing the defect rate in bread production. Through an in-depth case study and data analysis, it is expected to find effective strategies to improve product quality and production process efficiency. The research will also discuss the challenges faced by bread manufacturers in applying this method as well as the solutions that can be implemented.

By understanding and applying the Six Sigma method, it is expected that the bakery industry can increase its competitiveness in an increasingly competitive market [8]. The results of this study are expected to provide new insights for industry players, as well as a reference for further research in the application of Six Sigma methods in other food sectors.

Overall, the application of Six Sigma methods in bread production will not only reduce defects, but will also contribute to improved product quality and consumer satisfaction [9]. This research is expected to provide significant benefits to the bakery industry in Indonesia, while strengthening the foundation for better quality management practices in the future.

2. RESEARCH METHODE

This research uses the DMAIC method, which is a framework in Six Sigma for identifying and resolving quality problems. This method includes five stages: Define, Measure, Analyze, Improve, and Control.

a. The Define stage aims to set improvement goals that are in line with customer needs and company strategy, and identify the impact of existing problems ada [10].
b. At the Measure stage, process performance is measured by calculating the defect rate using the Defects Per Million Opportunities (DPMO) parameter to evaluate process capability against quality targets [11].
c. The Analyze stage is carried out to find the root cause of defects using cause-and-effect relationship analysis, so that improvement priorities can be determined appropriately [12].
d. The Improve stage aims to optimize the process by implementing specific improvement measures, such as Design of Experiments (DOE) to control process variables for best results [13].
e. The last stage, Control, focuses on continuous control to keep the improvement results consistent and in line with the Six Sigma target, which is no more than 3.4 defects per million opportunities [14].

This systematic DMAIC approach enables companies to reduce defect rates, improve process capability, and achieve greater operational efficiency [15].

3. RESULT AND ANALYSIS

3.1 Define Stage

The number of defects that occurred during the seven-day observation period was determined by this study. Table 1 shows that bread production continues to produce defective products, with daily changes in the number of defects. The cause is the lack of accuracy in the execution of work. The number of defective products during the observation period is shown in the table below.

Table 1. Report the Number of Defects During 7 Days of Observation

Day to	Number of Defevtive Products	Samples	Type of Defect			Proportion
			Size	Texture	Stuffing Comes Out	
1	40	300	15	7	18	0,133333
2	30	300	10	12	8	0,1

3	35	300	9	15	11	0,116667
4	33	300	11	13	9	0,11
5	43	300	13	18	12	0,143333
6	30	300	6	19	5	0,1
7	37	300	18	12	7	0,123333
Amount	248	2100	82	96	70	
				248		

As can be seen from the table above, the author collected a sample of 2100 pieces from Toko Fadhillah Bakery after 7 days of observation. During that time, 248 defects were found.

3.2 Measure Stage

The value of Fadillah Bakery's production quality attributes is assessed at the Measure stage using the company's Defect Per Million Opportunities (DPMO) and sigma level analysis.

1. Calculating the DPU (Defect Per Unit):
   $DPU = \frac{Total\ production\ defect}{Total\ Production}$
   Data 1, $DPU = \frac{40}{300} = 0{,}133333$
   Data 2, $DPU = \frac{30}{300} = 0{,}1$
   Data 3, $DPU = \frac{35}{300} = 0{,}116667$
   And so on until teh 7th data.
2. Calculating DPMO (Defect Per Million Oportunities)
   $DPMO = \frac{Total\ production\ defect}{Total\ Production} \times 1000000$
   Data 1, $DPMO = \frac{40}{300} \times 1000000 = 133333{,}3$
   Data 2, $DPMO = \frac{30}{300} \times 1000000 = 100000$
   Data 3, $DPMO = \frac{35}{300} \times 1000000 = 116666{,}7$
   And so on until teh 7th data.

So as to get the overall DPU and DPMO scores as follows.

Table 2. DPU and DPMO Calculation Data Results

Day to	Numbers of Samples	Numbers of Defects	DPU	DPMO	Sigma
1	300	40	0,133333	133333,3	2,110772
2	300	30	0,1	100000	2,281552
3	300	35	0,116667	116666,7	2,191816
4	300	33	0,11	110000	2,226528
5	300	43	0,143333	143333,3	2,065463
6	300	30	0,1	100000	2,281552
7	300	37	0,123333	123333,3	2,158484
Total	2100	248	0,826667	826666,7	15,31617
Average	300	35,4285714	0,118095	118095,2	2,188024

Fadillah Bakery's production area in the first observation has a sigma level of 2.11 with a potential defect of 133333.3 for one million production runs, as seen from the DPMO above. This area has a sigma level of 2.28 in the second observation, which means that a million times the production process can cause 100,000 pieces of damage. If the production process is not improved to reduce the number of product defects that occur in each production phase, this will certainly hurt the business.

3.3 Analyze Stage

Control Map Graph

To assess whether the defective products at Fadillah Bakery are still within the tolerable range or not, a control map graph is drawn at this point with the aim of identifying the upper and lower limits of control. The following formula is used in manual calculations:

1. Calculating Central Limit (CL)

$$\overline{P} = \frac{\sum_{i=1}^{g} Pi}{\sum_{i=1}^{g} ni} = \frac{248}{2100} = 0{,}118095$$

The following formula is used to determine the percentage of defects for each production run:

$$p = \frac{pi}{ni}$$

Samples for observation data 1 and 2 will then be collected.

$$p = \frac{40}{300} = 0{,}133333$$

$$p = \frac{30}{300} = 0{,}1$$

2. Determine the supervisory control limits by setting the LCL (lower control limit) and UCL (upper control limit) values.

$$UCL = \overline{P} + 3\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$$

$$UCL = 0{,}118095 + 3\sqrt{\frac{0{,}118095(1-0{,}118095)}{2100}} = 0{,}139222$$

$$LCL = \overline{P} - 3\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$$

$$LCL = 0{,}118095 - 3\sqrt{\frac{0{,}118095(1-0{,}118095)}{2100}} = 0{,}096968$$

Table 3. UCL and LCL Results Data for 7 Days of Observation

Observation	Total Disability	Total Sample	P	UCL	LCL	CL
1	40	300	0,133333	0,139222	0,096968	0,118095
2	30	300	0,1	0,139222	0,096968	0,118095
3	35	300	0,116667	0,139222	0,096968	0,118095
4	33	300	0,11	0,139222	0,096968	0,118095
5	43	300	0,143333	0,139222	0,096968	0,118095
6	30	300	0,1	0,139222	0,096968	0,118095
7	37	300	0,123333	0,139222	0,096968	0,118095
Total	248	2100				

A p-control map can then be created from the table mentioned above, as shown in Figure 1 below.

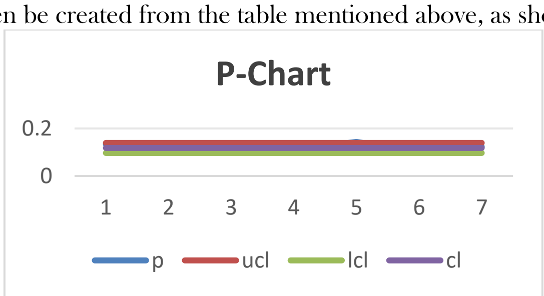

Figure 1. Control Map Graph

Cause Effect Diagram

The various potential causes of the problems that arose during the process are shown using a cause and effect diagram. The causal diagram in the figure below shows the information gathered from the job interviews about the factors contributing to the issue.

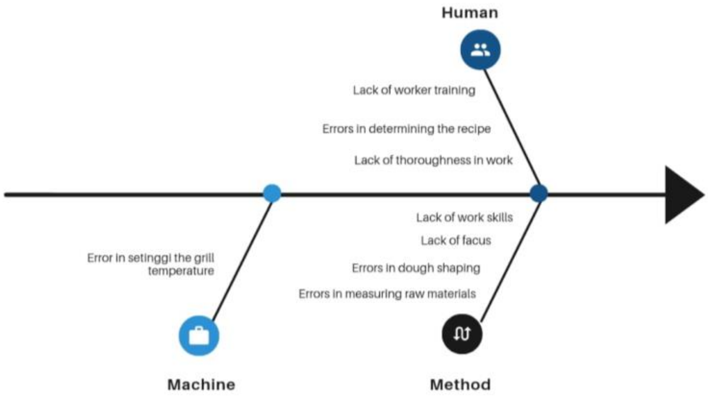

Figure 2. Cause Effect Diagram

Figure 2 explains that human issues, such as inadequate worker training, errors in recipe determination, and lack of accuracy in work, are the causes of bread production rejects at Fadillah Bakery. Method deficiencies including poor worker skills, lack of attention, errors in dough formation, and inaccurate measurement of raw materials can cause product damage during production. Machines make mistakes when changing the baking temperature, which can cause problems with the bread.

3.4 Improve Stage

When the causes of different types of product defects are identified, recommendations or general corrective actions are prepared in an attempt to lower the product defect rate. The improvement stage is a plan to avoid corrective actions and improve the quality of the products produced.

3.5 Control Stage

Controlling by implementing better approaches to correct anticipated deficiencies in the production process is the next step. Human factors, procedures, and machines are the main sources of all these problems. Therefore, the following are some of the ways that Fadillah Bakery can overcome various types of rejects by creating a defect management strategy:

1. High targets, labor shortages, and a limited number of machines make people less cautious, which leads to rejection. Aside from the potential expenses associated with hiring more staff and investing in new equipment, the company's preferred course of action is to encourage employees to feel more comfortable at work.
2. Rejects can also be caused by machine factors. Setting aside dedicated working hours for equipment maintenance is a control that needs to be implemented. Therefore, the plan is for businesses to develop a separate schedule for machine maintenance.
3. Rejection is also influenced by factors related to labor techniques. Workers' age, lack of training, haste to work, and pursuit of production targets all contribute to their lack of work ability. Therefore, necessary controls include arranging job placement, offering frequent training, strengthening supervision, and inspiring employees.

4. CONCLUSION

Based on the results of the above research, the application of the six sigma method with the DMAIC approach at Fadillah Bakery has succeeded in identifying and reducing the level of damage to bread products. From seven days of observation, 248 defective products were found from 2,100 samples, with an average Defects Per Million Opportunities (DPMO) of 118,095.2 and an average sigma level of 2.19. The highest defect rate occurred on the fifth day with a DPMO of 143,333.3 and a sigma level of 2.06. Control map analysis shows that most of the production process is still within the control limits, although there are deviations caused by human factors (lack of training and accuracy), methods (suboptimal processes), and machines (improper roasting temperature settings). Improvement efforts include increasing worker motivation, scheduling machine maintenance, and routine training and supervision. This control strategy is effective in reducing product defects, improving quality, and supporting the efficiency of the production process. With continuous control, Fadillah Bakery is expected to achieve higher quality standards and improve customer satisfaction.

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