Quality Improvement to Reduce Defective Rate of Bread Products Using Taguchi Method in UMKM Kembar Pastry

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ABSTRACT
Kembar Pastry is one of the Small Medium Enterprise (SME) in Kepri. There are relatively high defect products in the production process, namely 13.75% for small pillow bread. One of the causes of the high defect products is an inappropriate mixture of raw material composition and improper treatment settings. From these problems, it is necessary to improve product quality by determining the combination of raw materials and proper treatment settings to produce fewer defects using the Taguchi method and provide suggestions for improvements to enhance the quality of bakery products at Kembar Pastry. By using the Taguchi method, it can be seen what factors have a significant contribution to bread defects. The result of eight experiments showed that the optimal combination of factors and levels to produce the least defective product is the upper and lower flame temperature factor, the optimal temperature is 170^{o} C, the filling dose factor is 7 grams the burning time is 10 minutes. Suggestions for improvement for the company and the production process are the need for more detailed records, the required maintenance schedule, measuring spoons and dough molds, adding a weighing process before forming, and the use of rounding techniques.

***Keywords**: Quality, Defect, Experimental Design, Taguchi*

1. INTRODUCTION

The world economy is currently filled with industries whose types are starting to vary and one type of industry that has many business opportunities is the bread making business. Not all of the products produced by the company can reach the quality standards that have been set. One of the steps to maintain and improve product quality is to improve and control product quality. Bread defect data shows that the resulting defects for each type of bread are above 4%. Some examples of the application of Taguchi in improving product quality can be found, among others, in the study of dry shear wear of Al 7075 MMC [1], micro electro-chemical machining of Inconel Super-alloy [2], fly ash sintered lightweight concrete design [3], Micro screening neural network for physical and sensory characteristics of bread [4], epoxy-based concrete mix [5]), Taguchi has also been developed by combining other methods, namely for optimizing the durability of tarpaulins with Gray Relational Analysis [6], malathion biodegradation by Micrococcus aloeverae MAGK3 with incorporates metabolic pathway analysis [7].

The product to be tested is a small bread product because the types of defects are mostly found in small bread and the highest percentage of defects is in small bread, namely 13.75%. One of the causes of many damaged products is the inaccuracy of the mixture of raw material composition, treatment, and production process settings such as development time, printing method, temperature regulation, and combustion time. This study aims to avoid defects in bakery products through off-line quality control, namely the process and product design before arriving at production on the production floor and making improvements at the beginning of the process to produce high quality products. This method aims to create a more resilient product by determining which factors and level settings are appropriate during the production process so that the number of defective products produced is as minimal as possible.

2. METHODS

Conducted this research at the Kembar Pastry SME with the object of the study being a small pillow bread. The research material is primary data in the form of defect data for two months from July-August 2021, the types of defects produced are seven types, namely charred, deflated, leaking stuffing, uneven surface, not the same color, not the same size and sticking to the pan. Other primary data is the composition of raw materials and treatment settings in production. Quality improvement with the Taguchi method is carried out in 3 stages the first is the planning stage, the experimental implementation stage and the experimental result analysis stage. To analyze the factors causing product defects, a fishbone diagram is used. The fishbone diagram analysis results can determine independent variables, dependent variables, control factors, and disturbance factors. Making an orthogonal matrix using Minitab software is also used to analyze experimental data, including calculating the mean and Signal to Noise ratio, making means and S/N ranking graphs, predicting the optimum value, and calculating ANOVA. Analysis of variance is carried out to get the contribution of each factor to the resulting defective product.

3. RESULT AND DISCUSSION

The defects resulting from the production process are divided into seven types: charred, deflated, leaky filling, uneven color, uneven shape, uneven surface, and sticking to the pan. It is necessary to process data to determine the types of defects that will prioritize analyzing the problem. The following is data on defective products that are processed into a Pareto diagram and can be seen in Figure 1:

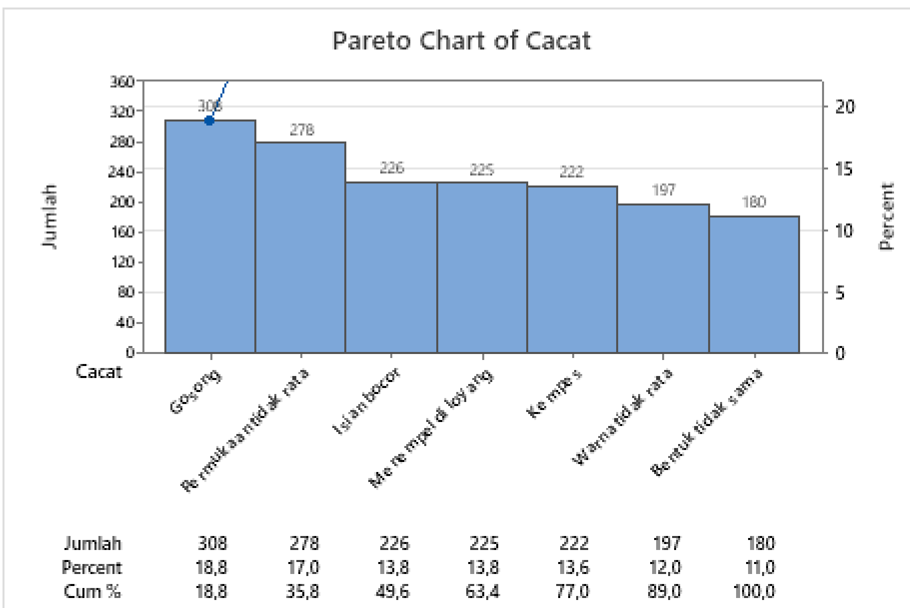

Figure 1. Pareto Diagram of Small Bread Defects in MSME Twin Pastry Period July-August 2021

The diagram above shows that the priority defect is a charred defect with the highest number of defects, namely 308 pcs, then uneven surface defects with 278 pcs defects. The third priority is leaky stuffing defects with 226 pcs defects. The first Taguchi experimental design stage is the planning stage which includes problem formulation, determining the testing objectives, namely determining the right mix of raw material composition, and treating the production process appropriately by obtaining optimal factor and level settings so that defective products are produced to a minimum, determining the dependent variable In this study, the percentage of bread defects, identification of factors (independent variables) was carried out using a fishbone diagram to analyze the cause and effect of the resulting defects, determining control factors and disturbance factors, determining the number of levels and factor level values which can be seen in table 1:

Table 1. Setting Factor and Level

No	Factor		Level 1	Level 2
1	A	Dosage yeast	12 gr	15 gr
2	B	Measuring filling	7 gr	10 gr
3	C	Proofing time 2	55 minutes	60 minutes
4	D	Burning time	10 minutes	12 minutes
5	E	Temperature up and down	170^o C	180^o C

Next is the calculation of the degrees of freedom to calculate the minimum number of experiments that must be carried out to investigate the experimental factors, and the results obtained from the calculation are 5 degrees of freedom. The stage of selecting the orthogonal matrix is based on each level's factor values and values. Some examples of research with different Orthogonal Arrays as in study with Orthogonal Array L_9 [1], Orthogonal Array $L_9(3^4)$ [4], Orthogonal Array L_{32} [5], Orthogonal Array L_2 [8], Orthogonal Array L_{16} (2^6) [9], Orthogonal Array L_9 (3^3) [10], Orthogonal Array L_{27} (3^{13}) [11], Orthogonal Array L_{18} (6^4) [12], Orthogonal Array L_{18} (3^4) [13]. While in this study using Orthogonal Array L_8 (2^5). Minitab is used to determine the orthogonal matrix with the results shown in Tables 2 and 3 below:

Array Table 2. Placement of Level Numbers into the Orthogonal

Run	Factor				
	A	B	C	D	E
1	1	1	1	1	1
2	1	1	1	2	2
3	1	2	2	1	1
4	1	2	2	2	2
5	2	1	2	1	2
6	2	1	2	2	1
7	2	2	1	1	2
8	2	2	1	2	1

Table 3. Orthogonal Array L_8 (2^5)

Run	Factor				
	Dosage yeast	Measuring filling	Proofing time 2	Burning time	Temperature up and down
1	12 gr	7 gr	55 minutes	10 minutes	170^oC
2	12 gr	7 gr	55 minutes	12 minutes	180^oC
3	12 gr	10 gr	60 minutes	10 minutes	170^oC
4	12 gr	10 gr	60 minutes	12 minutes	180^oC
5	15 gr	7 gr	60 minutes	10 minutes	180^oC
6	15 gr	7 gr	60 minutes	12 minutes	170^oC

Run	Factor				
	Dosage yeast	Measuring filling	Proofing time 2	Burning time	Temperature up and down
7	15 gr	10 gr	55 minutes	10 minutes	180 ºC
8	15 gr	10 gr	55 minutes	12 minutes	170 ºC

The second stage in the application of the Taguchi method is the stage of carrying out experiments which include the bread production process, before the experiment is carried out, improvements are made to the production process, including in the process of preparing tools and materials, the tools that will use in the bread production process are cleaned and designed, then placed in the place provided, the material to be used is opened from its packaging and prepared, the tools and materials are arranged in the order of use to facilitate the work and use a measuring spoon for consistent measurements. In the addition of the dough weighing process, the dough cut is considered first so that the size and weight of the bread are uniforms. It aims to get consistent production results, and the size of the bread produced does not change. In the process of printing and filling, the dough that has been cut into small pieces is then rounded, then flattened to give the filling a taste, after that the dough is kneaded tightly and rounded, then put back into the tin. The rounding technique is assisted by a grinder and a rotary table so that the print results are smoother, evenly rounded and of the same shape. Use molds that are the same shape and size. In the second proofing process, the dough that has been printed is then allowed to stand for approximately 1 hour until it expands again. In the second fermentation, careful supervision is carried out when taking the baking sheet so that the bread does not go flat due to wobbling or excessive hand movements. Then the process of baking bread is carried out at a firing temperature of 170-180oC depending on the weather and baking time. During the baking process, the baking pan is rotated so that the color of the bread produced is more even. Then an experiment was carried out with eight experiments, and from each experiment, one replication was carried out, the experimental results can be seen in Table 4 as follows:

Table 4. Experimental results using the Orthogonal Arrya design L_8 (2^5)

Run	Factor					Production result	Defect	%	Replica	%
	Dosag eyeast	Measuring filling	Proofing time 2	Burning time	Temperature up and down					
1	12 gr	7 gr	55 minutes	10 minutes	170ºC	47 pcs	3	6,38 %	1	2,12 %
2	12 gr	7 gr	55 minutes	12 minutes	180 ºC	48 pcs	5	10,41 %	2	4,16 %
3	12 gr	10 gr	60 minutes	10 minutes	170 ºC	48 pcs	4	8,33%	1	2,08 %
4	12 gr	10 gr	60 minutes	12 minutes	180 ºC	49 pcs	4	8,16 %	3	6,12 %
5	15 gr	7 gr	60 minutes	10 minutes	180 ºC	49 pcs	3	6,12 %	3	6,12 %
6	15 gr	7 gr	60 minutes	12 minutes	170 ºC	48 pcs	2	4,16 %	3	6,25 %
7	15 gr	10 gr	55 minutes	10 minutes	180 ºC	49 pcs	5	10,20 %	2	4,08 %

8	15 gr	10 gr	55 minutes	12 minutes	170 ºC	48 pcs	3	6,25 %	3	6,25 %

After obtaining the experimental results, the third stage is carried out, assisted namely the data analysis stage, in this study data analysis by using Minitab software, the first step was to calculate the means and signal to noise ratio values for each experiment and experimental results, the calculation results can be seen in Table 5 as follows:

Table 5. Value of Means and Signal to Noise Ratio

Run	*SNRA*	*MEAN*
1	*-6,9897*	*2,0*
2	*-11,6137*	*3,5*
3	*-9,2942*	*2,5*
4	*-10,9691*	*3,5*
5	*-9,5424*	*3*
6	*-8,1291*	*2,5*
7	*-11,6137*	*3,5*
8	*-9,5424*	*3,0*

Calculation of the influence of factors on the average defect of bread, this stage is carried out to obtain optimum factors with the characteristics of the smaller the defect response, the better (smaller is the better), the results of the calculation can be seen in Table 6 as follows:

Table 6. Response Table for Means

Level	**Dosage yeast**	**Measuring filling**	**Proofing time 2**	**Burning time**	**Temperature up and down**
1	2,875	2,750	3,000	2,750	2,500
2	3,000	3,125	2,875	3,125	3,375
Delta	0,125	0,375	0,125	0,375	0,875
Rank	4,5	2,5	4,5	2,5	1

The measure of the influence of factors on the signal to noise ratio, this stage is carried out to obtain optimum factors with the characteristics of the response value of S/N the smaller the better (smaller is the better), the calculation results can be seen in Table 7 as follows:

Table 7. Response Table for Signal to Noise Ratio

Level	**Dosage yeast**	**Measuring filling**	**Proofing time 2**	**Burning time**	**Temperature up and down**
1	-9,717	-9,069	-9,940	-9,360	-8,489
2	-9,707	-10,355	-9,484	-10,064	-10,935
Delta	0,010	1,286	0,456	0,704	2,446
Rank	5	2	4	3	1

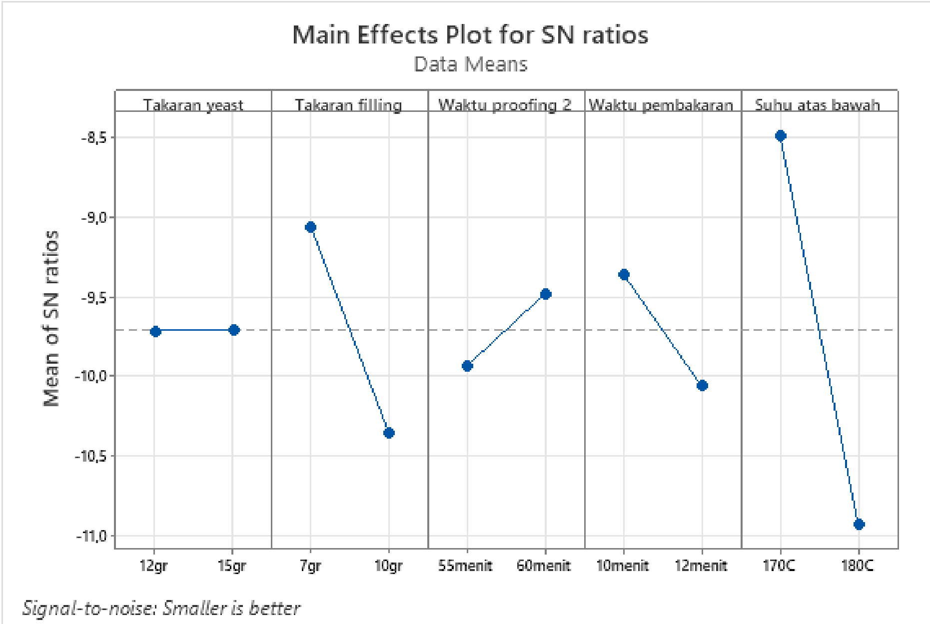

Figure 2. Main Effects Plot for S/N Ratio

Because L8 (25) has 5 degrees of freedom, half of the degrees are an important influence or significant factor. In this study, there are five factors, and then three factors are taken as factors that have an important impact on the average defect of bread with the characteristics of the smaller the better (smaller is the better). Based on the picture above, it can seem that the most significant S/N Ratio values based on existing rankings are: Rank 1 is at the top and bottom temperature factor level 1 with a value of 170º C (E1), Rank 2 is at the filling dose factor level 1 with a weight of 7 gr. (B1), and Rank 3 are at level 1 burning time factor with 10 minutes (D1). The next step is to calculate the estimated bread means to value and the Signal to Noise Ratio value for the optimum response conditions, the calculation results can be seen in Table 8 as follows:

Table 4. 25 Predicted Value of S/N Ratio and Mean

S/N Ratio	Mean	StDev	Ln(StDev)
-7,77855	2,16667	1,88562	0,664831

Using the Taguchi method, the average value of product defects produced when applying the optimum factor and level experienced a decrease in defective products by 26, 27%. The value of the S/N ratio of product defects produced when applying the optimum factor and level using the Taguchi method decreased by 19, 97%. The next step is the calculation of the analysis of variance on the variability of the bread defect, the analysis of variance is carried out to know the contribution of each factor and which factor gives the most significant contribution to the variability of the defect in bread. The results of the analysis can be seen in Table 9 below:

Table 9. Analysis of Variance on bread defect variability

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Temperature up and down	1	11,9645	63,10%	11,9645	11,9645	17,73	0,014
Measuring filling	1	3,3082	17,45%	3,3082	3,3082	4,90	0,091
Burning time	1	0,9901	5,22%	0,9901	0,9901	1,47	0,292
Error	4	2,6988	14,23%	2,6988	0,6747		

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Total	7	18,9615	100,00%				

The value used in the analysis of variance is = 0.5 / 50%, the value illustrates that we will accept a 50% possibility of error in classifying essential factors, the factor that contributes the largest to the bread defect variability is the top and bottom temperature factor with a value of 63, 10%, and the second contribution percent is the filling dose factor with a value of 17, 45%, and the element with the third-largest contribution is the combustion time factor with a value of 5, 22%. The last step is the calculation of the analysis of variance on the average defect of bread, the results of the analysis of variance can be seen in Table 10 as follows:

Table 10. Analysis of Variance using the value of = 0.25

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Suhu atas bawah	1	1,5313	69,01%	1,5313	1,53125	49,00	0,002
Takaran filling	1	0,2812	12,68%	0,2812	0,28125	9,00	0,040
Waktu pembakaran	1	0,2813	12,68%	0,2813	0,28125	9,00	0,040
Error	4	0,1250	5,63%	0,1250	0,03125		
Total	7	2,2188	100,00%				

It shows that the factor that gives the most significant contribution to the average defect of bread is the upper and lower temperature factor with a value of 69.01% and the second contribution percentage is the filling dose factor with a value of 12, 68% and the factor with the third-largest contribution is the burning time factor with a value of 12.68%.

4. CONCLUSION

Based on the analysis and discussion in chapter 4, the conclusions that be drawn from this research are as follows: Setting and composition of raw materials that produce a minimum defect of bread, namely the combustion process at a firing temperature up and down of 170^o C (E1), time the burning used is 10 minutes (D1) and the composition of the filling is 7 grams (B1). From the conclusions that have been obtained, it can submit it suggestions for companies and further research with the same problem then the next thing to do is: UMKM Kembar Pastry can apply optimal factor and level settings in the bread production process to minimize the resulting defective products and reduce the resulting faulty effects. It is necessary to have records for the number of production targets each day, the number of productions, the number of defective products, and more detailed specifications of faulty products. It is necessary to schedule the machines used in the production process, namely ovens and mixers.It is expected that the Kembar Pastry can implement the following production process improvements: Tools and materials to be used are arranged to make the job easier. Use a measuring spoon for consistency of raw materials. The cut dough is weighed first so that the size and weight are the same. And use the rounding technique for the molding process with the help of a rotary table and a grinder, use a mold of the same size and shape when placing the dough into the pan.

ACKNOWLEDGEMENT

Greetings and Happiness, Peace be upon you, and Allah's mercy and blessings, Praise and gratitude the author pray to Allah SWT. The latter has bestowed His grace and guidance to the author so that the author can complete the preparation of the Final Project Report with the title "Improving Quality To Reduce Bread Product Defects By Using the Taguchi Method in MSME Twin Pastry" on time. The author say thanks to the Industrial Engineering Study Program, Faculty of Engineering, and Sarjanawiyata Tamansiswa Univesity Yogyakarta. The writing of this final research report cannot be separated from the guidance, direction, and assistance from various parties that cannot mention one by one. The Twin Pastry Umkm who have permitted me to observe to compile this final report. May Allah repays the kindness that has been given to Allah with a better one. Allah SWT is the only owner of perfection and excellent knowledge. We hope that this practical work report will be of use to readers. Amen Allahumma Amen.

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