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OPTIMIZATION OF SYAHFIRA BAKERY PRODUCTION USING THE TAGUCHI-PRINCIPAL COMPONENT ANALYSIS (PCA) METHOD

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ABSTRACT

The bread-making business is part of the finished food industry which uses wheat flour as the main raw material for its production process. Bread production has quality characteristics, namely bread surface roughness (Smaller is better) and material processing rate (Larger is better). The combination of the Taguchi-Principal Component Analysis method is used to optimize bread products. The experimental design used is the L9 orthogonal matrix. These quality characteristics are influenced by factors such as the length of time for mixing and kneading, yeast fermentation, roasting time and the dose of water with 3 levels each. Principal Component Analysis (PCA) is used to eliminate correlated correlated responses to an uncorrelated quality index. The results showed that this method can improve the quality of bread production in influencing the surface roughness of the bread and the significant speed of processing the ingredients is the dough time, yeast fermentation, and baking time.

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1. INTRODUCTION

One of the culinary businesses that are quite in demand today is the business of making bread. Bread making business is part of the ready-to-eat food industry that uses wheat flour as the main raw material for its production process. Bread making business is one of the businesses that is growing quite rapidly in Medan compared to other businesses. Syahfira bakery shop is one of the bakery SMEs in the city of Medan. The beginning of the establishment of the Syahfira Bakery shop in 2015 until now. The scope of Syahfira Bakery's line of business is to produce bread, donuts, and sponge cakes. Bread produced with various flavors including original taste, chocolate flavor, cheese, coconut, mocca, and others.

The production of Syahfira Bakery has not known the factors and levels that affect the quality of bread production. The production carried out by the company so far is only based on experience without any prior planning. So the Taguchi method is used to produce an optimal combination of factors and levels to increase the production of Syahfira Bakery's bread. The combination of Taguchi-Principal Component Analysis (PCA) method is used to optimize bread production. The Taguchi method is only capable of optimizing one response, so for multiresponse the Principal Component Analysis (PCA) method is used.

2. RESEARCH METHOD

The variables studied are the factors that influence the bread production process which were determined by the researchers to be studied and then drawn conclusions.

In this case study, two response variables are used, namely:

1. Bread Surface Roughness

Having an optimal response characteristic is that the smaller the better the Smaller-is-Better.

2. Machining Rate of Material

It has a larger response characteristic, the better the Larger-is-Better.

3. RESULT AND ANALYSIS

1. Preparation Stage

The data used in this research is bread production data with optimal response, namely surface roughness and material processing rate. There are four factors where each factor has three levels.The Taguchi-Principal Component Analysis (PCA) method is used to optimize factors and levels so as to produce a better response.

Table 1 Variables Under Study

Control Factor	Level		
	1	2	3
Mixing and kneading time	20	40	60
Yeast Fermentation	45	90	135
Baking Time	35	70	105
Water Dosage	650	1500	2150

2. Selection of Orthogonal Matrix

The standard orthogonal matrix with three levels has several choices of orthogonal matrices as shown in Table 1.

Table 2 Three Level Orthogonal Matrix

Three Level Orthogonal Matrix		
$L_9(3^4)$	$L^{27}(3^{13})$	$L_{81}(3^{10})$

The calculation for $L_9(3^4)$is of appropriate as the degrees

Degrees of Freedom = (many factors) (many degrees of -1) = 4 (3-1)=8 the number of degrees freedom at the time of the experiment = degrees of freedom at $L_9(3^4)$). So that $L_9(3^4)$) is and sufficient because the orthogonal matrix $L_9(3^4)$has the same degrees of freedom of freedom used during the 9 experiments.

Table 3 Matriks Orthogonal $L_9(3^4)$

Faktor			
Mixing and kneading time	Yeast Fermentation	Baking Time	Water Dosage
20	45	35	650
20	90	70	1500
20	135	105	2150
40	45	70	2150
40	90	105	650
40	135	35	1500
60	45	105	1500
60	90	35	2150
60	135	70	650

3. Signal Noise to Ratio (SNR)

The value of S/N Ratio is the transformation value of several repetitions of data whose value represents the quality of presentation in bread production. In this case there are 2 response characters. First, the response character of the surface roughness (Smaller is Better) can be calculated according to the following equation:

$$S/N = -10\log\left[\sum_{i=1}^{n}\frac{y_i^2}{n}\right]$$

$$= -10\log\left[\frac{(0,18)^2+(0,16)^2+(0,26)^2}{3}\right]$$

$$= -10\log\left[\frac{0,0324+0,0256+0,0676}{3}\right]$$

$$= -10\log\frac{0,1256}{3}$$

$$= -10\log 0,041866666$$

$$= 13,78132$$

Table 4. Calculation of S/N Ratio

S/N Ratio	
Larger	*Smaller*
13,78132	-14,50863
18,92790	-20,68881
12,03888	-12,51007
16,84730	-17,82675
23,43582	-23,75240
19,82967	-24,12752
9,85200	-10,03414
15,74031	-16,48383
8,53872	-8,61847

4. Ratio Normalization

Normalization aims to transform the value of the S/N Ratio so that it is between 0 and 1. The normalization process is also carried out based on the characteristics of the response quality. Normalization of the S/N Ratio on the response to the hardness of the bread surface (Smaller is Better) with the S/N Ratio value of -14,50863 the minimum S/N Ratio value of -24.12752 and the Maximum S/N Ratio of -8.61847.

Table 5 Normalization Calculation Results

Normalisasi	
Larger	Smaller
0,35192	0,37979
0,69740	0,77828
0,23496	0,25092
0,55773	0,59374
1,00000	0,97581
0,75793	1,00000
0,08816	0,09128
0,48342	0,50715
0,00000	0,00000

Table 6 Pearson Correlation Coefficient

Variable	PC_1	PC_2
X_i*Sn	0,707	0,707
X_i*Ln	0,707	-0,707

Table 7 Results of PCA

	Z1	Z2
Eigen Value	1,9789	0,0211
Eigen Vector	0,707	0,707
	0,707	-0,707
Proportion	0,989	0,011
Cumulative	0,989	1

5. Calculating Principal Component Analysis (PCA)

Then the correlation value between responses is converted into a quality called the principal component. for example the calculation process to find the value of PC1 and also PC2. On the first try PC1

$$Z_j = \sum_{i=1}^{p} a_{ji} Y_i$$
$$= (0,707 \times 0,35192) + (0,707 \times 0,37979)$$
$$= 0,24880744 + 0,26851153$$
$$= 0,517318$$

6. Calculating the Multi-Response Performance Index (MPI)

The MPI results are used for optimal settings for levels and factors in bread production.

7. Analysis of Variance (ANAVA)

ANAVA or analysis of variance, is used to find the magnitude of the influence of each control parameter on a process.

8. Discussion

At the beginning of the process, 4 factors were used where these factors were the length of mixing and kneading time with significant results at level 2, yeast fermentation with significant results at level 2, length of roasting time with significant results at level 1 and the amount of water with significant results at level 1 2. However, when the ANOVA test was carried out, the water dose was not significant because the water dose did not affect the response to the quality of bread production at the Syahfira Bakery shop. Then the analysis of variance was carried out again without using the water dose factor, the length of time for mixing and kneading the yeast fermentation factor was significant, meaning that significant factors had an influence on the production of good quality bread.
Meanwhile, the bread production process carried out by humans depends on factors that affect the quality of bread production, which on these factors produce optimal production quality.

4. CONCLUSION

The Taguchi method with the Principal Component Analysis (PCA) approach can be used to optimize bread production, where the Taguchi method aims to improve product quality and can reduce costs and resources to a minimum which generally has one response, while the Principal Component Analysis (PCA) approach is used in optimization to change some responses so that the experimental design becomes more effective and efficient. Factors that significantly affect the quality response of bread production are 40 minutes of mixing and kneading time, 90 minutes of yeast fermentation, 35 minutes of baking time. So that the optimum combination of factors and levels can be applied to improve the quality of bread production. The yeast dose is not significant to the response of bread surface roughness and the rate of material processing. The contribution of the bread production variables in reducing the total variance of the bread production quality response is the length of mixing and kneading time 51.51%, yeast fermentation 28.41%, length of time baking 6.75% .

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