3. RESULTS

After 10 days of fermentation, *nata de coco* sheet was harvested and cleaned. The initial physical properties of this *nata de coco* sheet (Figure 7) were measured. The initial thickness, hardness, L* value, a* value, and b* value of *nata de coco* respectively were 1.452±0.185 cm, 565.702±204.824 gf, 54.494±4.199, 1.072±0.269 and -4.473±1.736. Based on the experimental design obtained from the SYSTAT, 16 groups of boiled *nata de coco* cube were used for the analysis. These 16 groups of *nata de coco* cube were analyzed for their physical properties such as thickness, hardness, and color.

Figure 7. *Nata de coco* Sheet

Table 3 shows the thickness, hardness and color (L*, a*, and b* value) of *nata de coco* for the 16 experimental conditions. The values shown are mean ± standard deviation of 20 replicates. Table 3 shows that different combination of the three variables gives various responses. The thickness and hardness of *nata de coco* of all the 16 experimental combinations was in the region of 1.8 - 2.2 cm and 370 to 520 gf respectively. All the *nata* from 16 experimental combinations have white color which shown in high L* value and low a* and b* value.

Table 3. Physical Properties of *Nata de coco* at Different Boiling Condition

Run	Water Ratio	Boiling Time	Boiling Repetition	Thickness (cm)	L*	a*	b*	Hardness (gf)
1	1:4	5	2	1.809 ± 0.098	54.346 ± 1.766	0.024 ± 0.102	-4.697 ± 0.403	372.230 ± 59.290
2	1:6	5	2	1.976 ± 0.084	54.006 ± 2.398	0.043 ± 0.213	-5.603 ± 0.757	421.767 ± 82.248
3	1:4	9	2	2.033 ± 0.100	53.472 ± 1.947	0.031 ± 0.192	-5.677 ± 0.586	444.462 ± 120.419
4	1:6	9	2	2.007 ± 0.111	52.898 ± 1.932	0.049 ± 0.221	-5.639 ± 0.491	431.507 ± 100.080
5	1:4	5	4	2.039 ± 0.121	52.096 ± 1.269	0.020 ± 0.195	-5.836 ± 0.582	431.874 ± 132.727
6	1:6	5	4	2.060 ± 0.084	51.237 ± 1.910	0.058 ± 0.263	-5.651 ± 0.447	408.598 ± 126.577
7	1:4	9	4	2.158 ± 0.114	53.714 ± 1.940	0.026 ± 0.166	-5.783 ± 0.677	407.046 ± 101.705
8	1:6	9	4	2.122 ± 0.102	53.997 ± 2.097	-0.021 ± 0.203	-5.758 ± 0.554	474.895 ± 105.512
9	1:3	7	3	2.195 ± 0.145	61.472 ± 1.369	0.160 ± 0.165	-3.885 ± 0.530	519.835 ± 120.012
10	1:7	7	3	2.164 ± 0.136	62.436 ± 1.292	0.212 ± 0.139	-3.931 ± 0.237	509.017 ± 132.946
11	1:5	3	3	2.134 ± 0.139	62.762 ± 1.502	0.232 ± 0.159	-3.926 ± 0.306	494.605 ± 139.145
12	1:5	11	3	2.087 ± 0.141	61.615 ± 1.311	0.277 ± 0.221	-3.809 ± 0.322	434.114 ± 134.255
13	1:5	7	1	2.111 ± 0.088	61.378 ± 1.836	0.193 ± 0.199	-3.712 ± 0.382	374.244 ± 113.366
14	1:5	7	5	2.112 ± 0.090	62.631 ± 1.618	0.216 ± 0.156	-3.867 ± 0.380	409.230 ± 70.255
15	1:5	7	3	2.016 ± 0.154	63.038 ± 1.884	0.124 ± 0.123	-3.933 ± 0.347	389.834 ± 121.532
16	1:5	7	3	2.123 ± 0.090	62.082 ± 1.720	0.124 ± 0.201	-3.898 ± 0.320	377.029 ± 146.886

In order to understand the result better, the data in Table 3 is shown in form of graphs below. Each of the response will be presented in a bar chart which shows the response after each boiling condition.

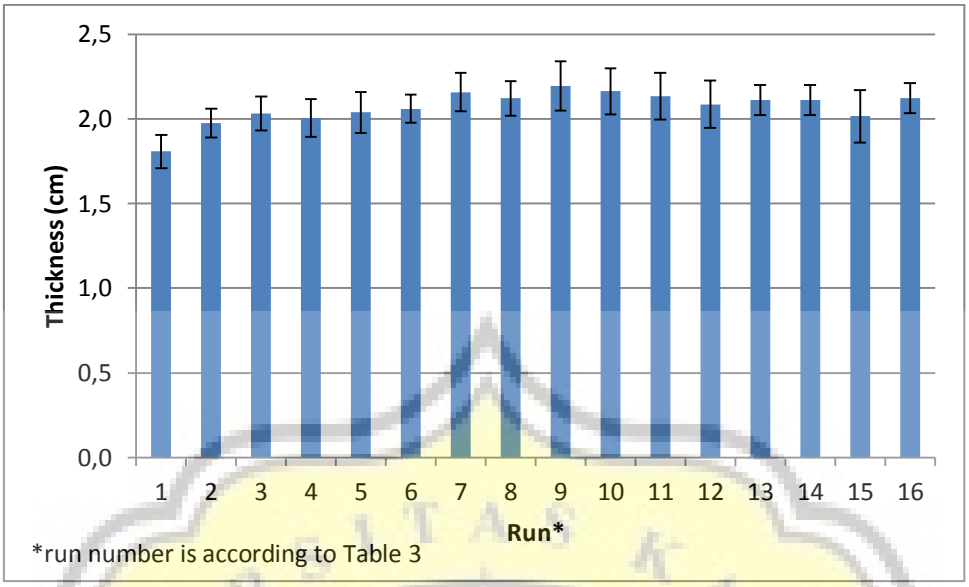

Figure 8. Thickness of *Nata de Coco* after Various Boiling Condition

Figure 8 shows the thickness of *nata de coco* after various boiling condition. Boiling condition of *nata* and water ratio of 1:3, boiling time 7 minutes, and boiling repeated 3 times resulted in *nata* with the highest thickness. Boiling condition of *nata* and water ratio of 1:4, boiling time 5 minutes, and boiling repeated 2 times resulted in *nata* with the lowest thickness. Highest thickness is desirable as it indicates thicker *nata de coco*.

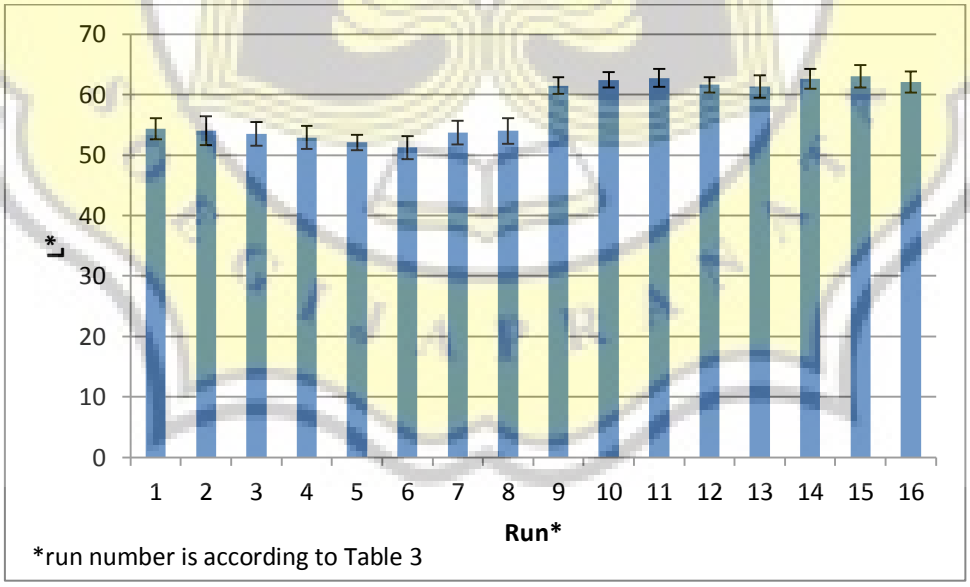

Figure 9. L* Value of *Nata de Coco* after Various Boiling Condition

Figure 9 shows the L* value of *nata de coco* after various boiling condition. The highest L* value was reached in boiling condition of *nata* and water ratio of 1:5, boiling time 7

minutes, and boiling repeated 3 times. Boiling condition of *nata* and water ratio of 1:6, boiling time 5 minutes, and boiling repeated 4 times result on the lowest L* value. Highest L* value is desirable as it indicates lighter color of *nata de coco*.

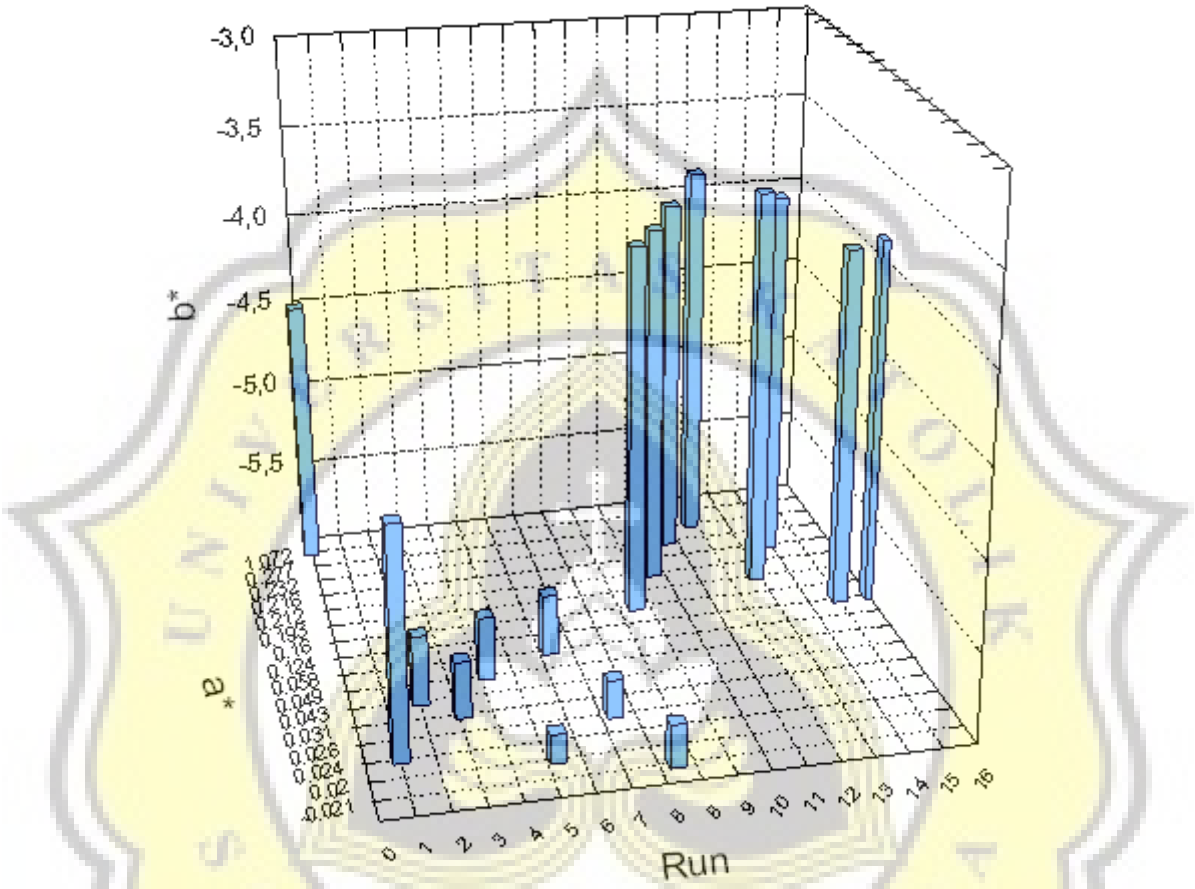

Figure 10. a* and b* value of *Nata de Coco* after Various Boiling Condition

Figure 10 shows the a* and b* value of *nata de coco* after various boiling condition. Run number 0 explains the pre-boiling condition or the initial condition of *nata de coco*. Run number 1-16 are according to Table 3. The boiling combination that result in lowest a* (shown in the closest bar to run axes) and lowest b* value (shown in the highest bar) is desirable as it indicates white color of *nata de coco*. Boiling condition of *nata* and water ratio of 1:5, boiling time 7 minutes, and boiling repeated 3 times resulted on the lowest a* and b* value. The highest a* and b* value was reached in boiling condition of *nata* and water ratio of 1:4, boiling time 5 minutes, and boiling repeated 4 times.

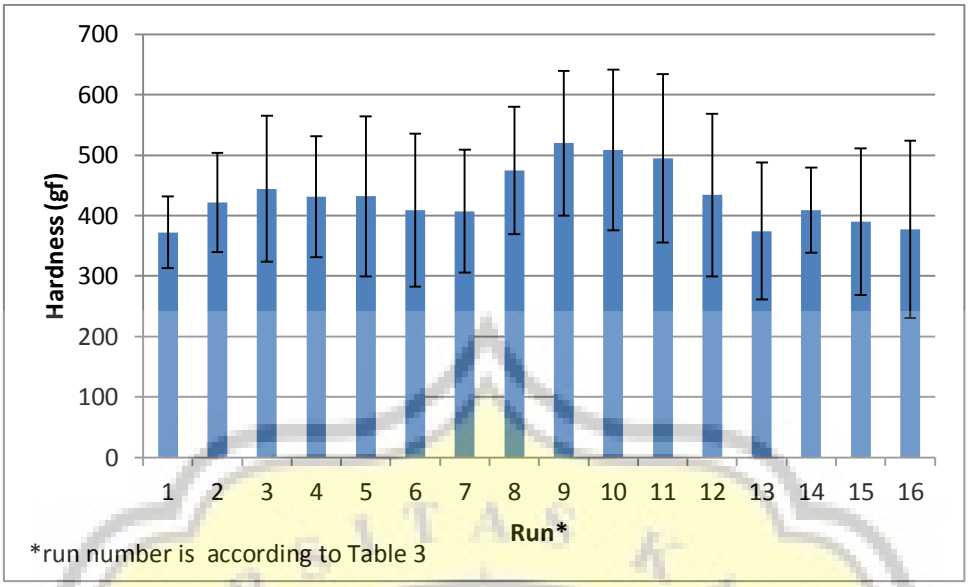

Figure 11. Hardness of *Nata de Coco* after Various Boiling Condition

Figure 11 shows the hardness of *nata de coco* after various boiling condition. Boiling condition of *nata* and water ratio of 1:3, boiling time 7 minutes, and boiling repeated 3 times resulted in *nata* with the highest thickness. Boiling condition of *nata* and water ratio of 1:4, boiling time 5 minutes, and boiling repeated 2 times resulted in *nata* with the lowest thickness. Lowest hardness is desirable as it indicate soft texture of *nata de coco*.

Table 4. Regression Coefficients and R^2 values

Coefficient	Y_1	Y_2	Y_3	Y_4	Y_5
Constant	1.796*	62.933*	0.583	1.445*	1,443.823*
X_1	-0.103	1.019	-0.093	-0.813	-339.289
X_2	0.067*	-1.148	-0.070	-0.493	-72.089
X_3	0.102*	-2.234	-0.057	-1.391	7.918
X_1^2	0.028*	-0.152	0.016	0.002	32.749*
X_2^2	0.003	-0.023	0.008*	0.003	5.058*
X_3^2	0.010	-0.139	0.020	0.031	2.076
X_1*X_2	-0.016*	0.057	-0.005	0.049	1.790
X_2*X_3	-0.005	0.397*	-0.005	0.060	-2.531
X_1*X_3	-0.019	0.042	-0.006	0.135	0.999
R^2	0.153	0.015	0.031	0.038	0.105

X_1 : Water ratio, X_2 : Boiling time, X_3 : Boiling repetition
Y_1 : Thickness, Y_2 : L*, Y_3 : a*, Y_4 : b*, Y_5 : Hardness
* Significant at $P < 0.05$

Table 4 shows the estimated regression coefficients for each response and their statistical significances. Table 4 exhibits that water ratio (X_1) was not significant to any of the responses tested. Boiling time (X_2) and boiling repetition (X_3) were significant to thickness of *nata de coco*, but not significant to other responses. The quadratic function of water ratio (X_1^2) was significant for thickness and hardness, while the quadratic function of boiling time (X_2^2) was significant for a* and hardness. Water ratio-boiling time interaction (X_1X_2) was significant for thickness, while boiling time-boiling repetition interaction (X_2X_3) was significant for L*. The quadratic function of boiling repetition (X_3^2) and water ratio-boiling repetition interaction (X_1X_3) were not significant for any responses within the range of this study. Table 4 also lists the satisfactory values of R^2 for each response. In this experiment, the highest R^2 value obtained is 0.153 for the thickness. The hardness R^2 value is the second highest at 0.105. The R^2 value for L*, a*, and b* respectively are 0.015, 0.031, and 0.038.

Based on the significant regression coefficients on Table 4, the empirical function of each response were shown in the equation below.

$$Y_1 = 1.796 + 0.067x_2 + 0.102x_3 + 0.028x_1^2 - 0.016x_1x_2$$

$$Y_2 = 62.933 + 0.397\, x_2x_3$$

$$Y_3 = 0.008x_2^2$$

$$Y_4 = 1.445$$

$$Y_5 = 1{,}443.823 + 32.749x_1^2 + 5.058x_2^2$$

Table 5. Analysis of Variance and Lack of Fit Result

Source	P value				
	Y_1	Y_2	Y_3	Y_4	Y_5
Regression	0,000	0,854	0,351	0,197	0,000
Linear	0,000	0,994	0,903	0,155	0,637
Quadratic	0,004	0,945	0,039	0,941	0,000
Interaction	0,006	0,233	0,800	0,083	0,927
Lack of fit	0.000	0.000	0.000	0.000	0.033

Y_1 : Thickness, Y_2 : L*, Y_3 : a*, Y_4 : b*, Y_5 : Hardness

The results of the analysis of variance and lack of fit test for responses (thickness, hardness and color of *nata de coco*) of boiling condition (water ratio, boiling time, and boiling repetition) are shown in Table 5. P values in Table 5 indicate that the regression

for L*, a*, and b* were not significant. In term of regression equation, thickness has significant relationship with water ratio, boiling time, and boiling repetition i.e. linear, quadratic, and the interaction. Meanwhile, hardness has only shown significant quadratic relationship. Results of lack of fit test indicate the inadequacy ($P > 0.05$) of the fitted response surface model, except for hardness ($P > 0.1$).

Table 6. Canonical Analysis of Response Surface

Dependent Variable	Critical Values			Predicted Optimal Value	Stationary Point
	Water Ratio	Boiling Time	Boiling Repetition		
Thickness	7.107	12.731	4.557	2.085	Saddle
L*	5.121	7.168	2.994	58.084	Saddle
a*	4.696	6.827	2.961	0.041	Minimum
b*	5.402	7.868	3.021	-4.792	Saddle
Hardness	4.991	6.449	0.824	367.849	Minimum

Table 6 shows that there are different optimum boiling conditions for each response. The characteristic of stationary points for thickness, L*, and b* were a saddle point. This indicated that the predicted optimal values for thickness, L*, and b* actually were neither a maximum nor a minimum. The stationary points for hardness and a* were showing a minimum characteristic. This means that minimum hardness and a* can be obtained when the *nata* boiled with the critical value shown in Table 6.

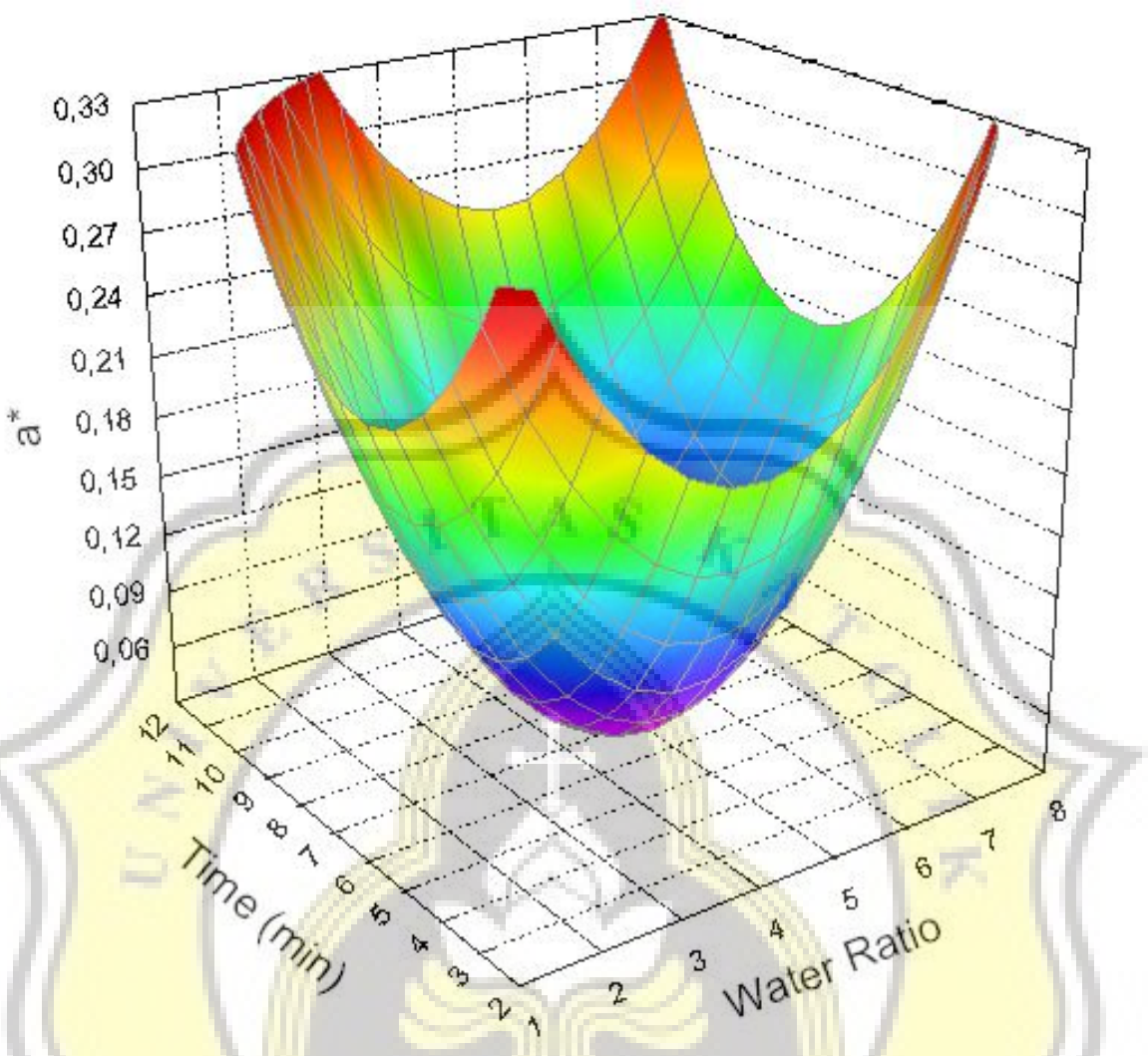

Figure 12. Surface Plot of a* at Different Water Ratio and Boiling Time

Figure 12 showed the surface plot of a* value at different water ratio and boiling time. The surface plot was a graphical representation of Y_3 regression equation based on Table 4. The surface plots take a convex shape. Therefore minimum a* value can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).

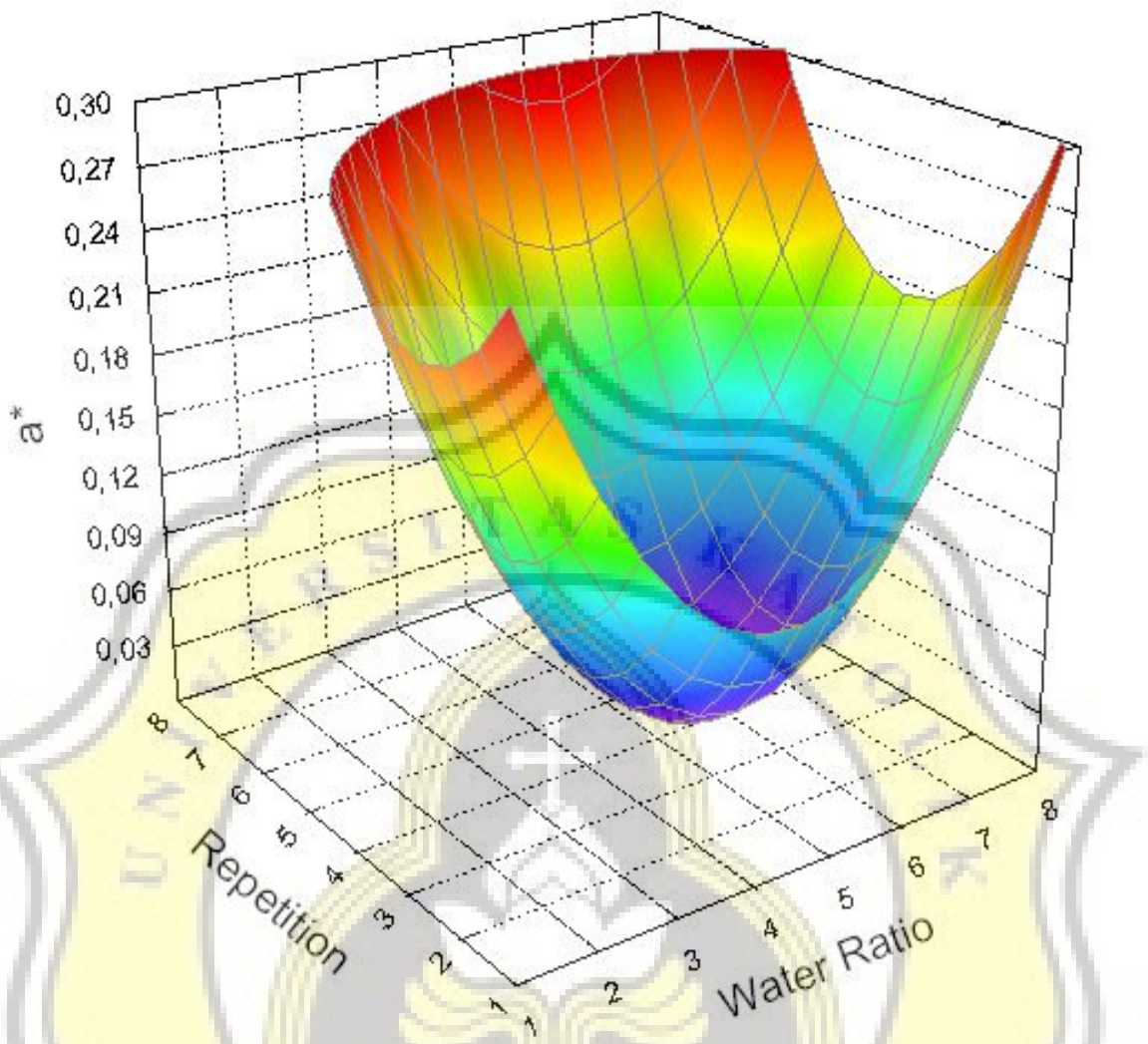

Figure 13. Surface Plot of a* at Different Water Ratio and Boiling Repetition

Figure 13 showed the surface plot of a* value at different water ratio and boiling repetition. The surface plot was a graphical representation of Y_3 regression equation based on Table 4. The surface plots take a convex shape. Therefore minimum a* value can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).

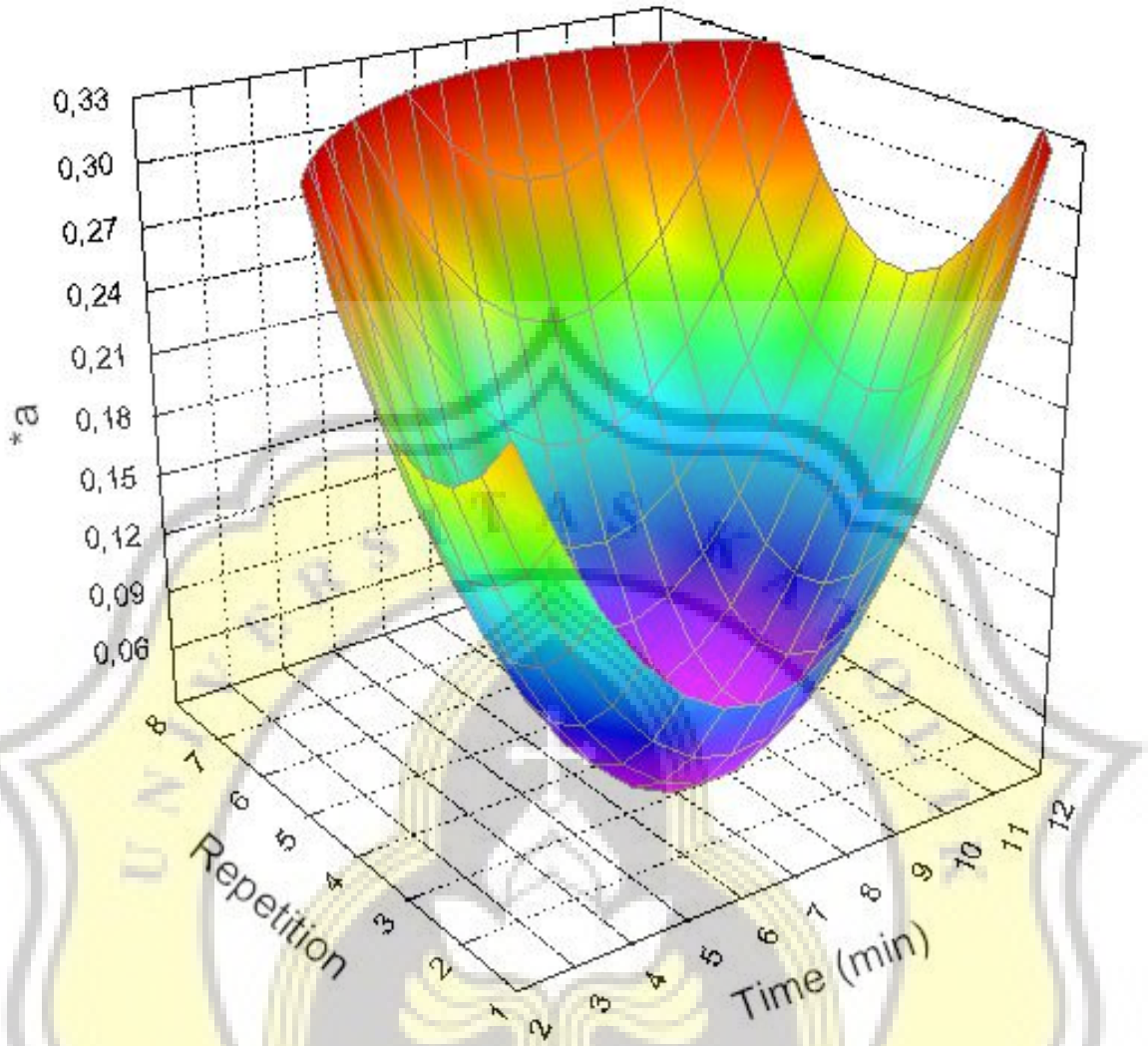

Figure 14. Surface Plot of a* at Different Boiling Time and Boiling Repetition

Figure 14 showed the surface plot of a* value at different boiling time and boiling repetition. The surface plot was a graphical representation of Y_3 regression equation based on Table 4. The surface plots take a convex shape. Therefore minimum a* value can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).

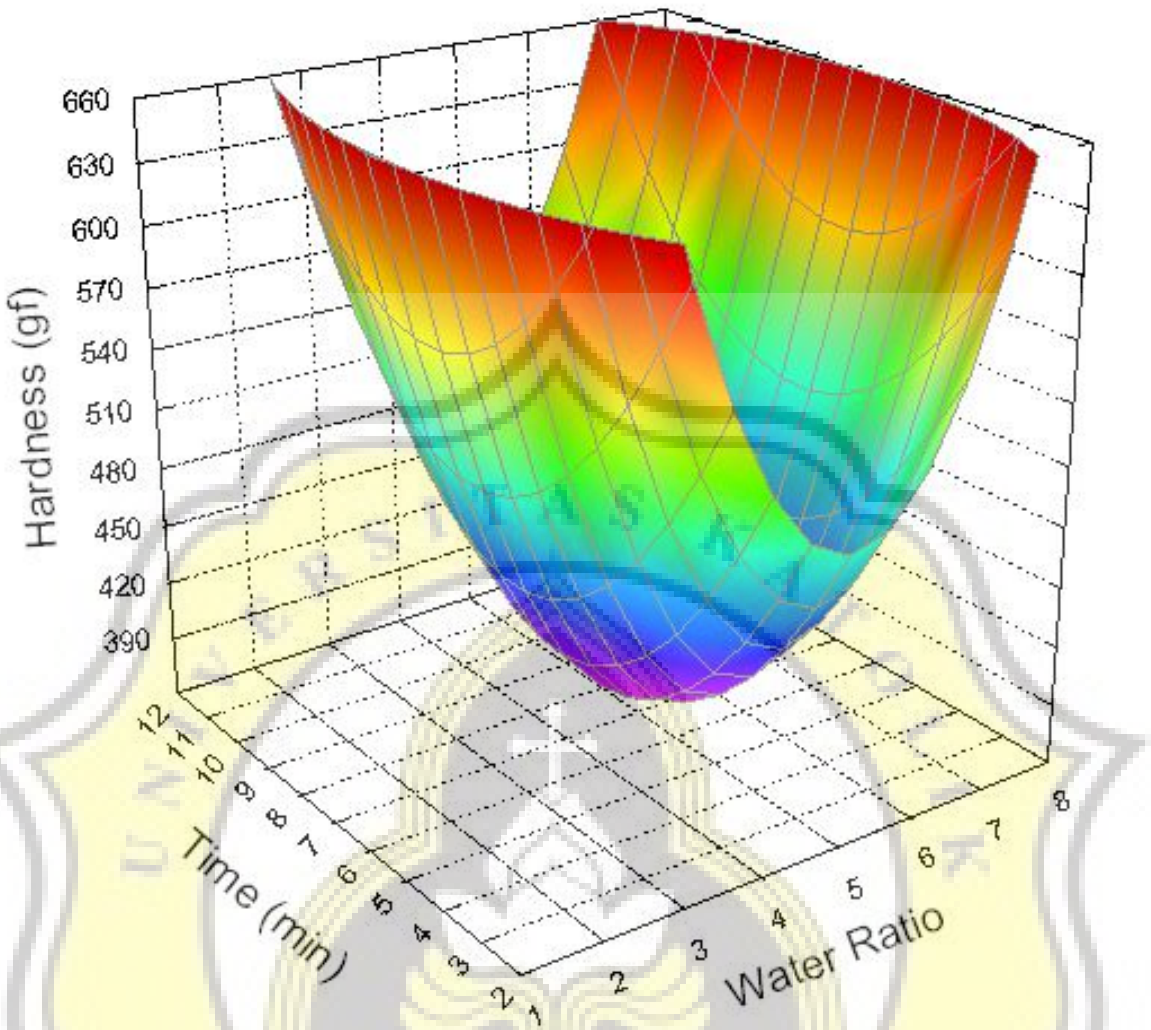

Figure 15. Surface Plot of Hardness at Different Water Ratio and Boiling Time

Figure 15 showed the surface plot of hardness at different water ratio and boiling time. The surface plot was a graphical representation of Y_5 regression equation based on Table 4. The surface plots take a convex shape. Minimum hardness can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).

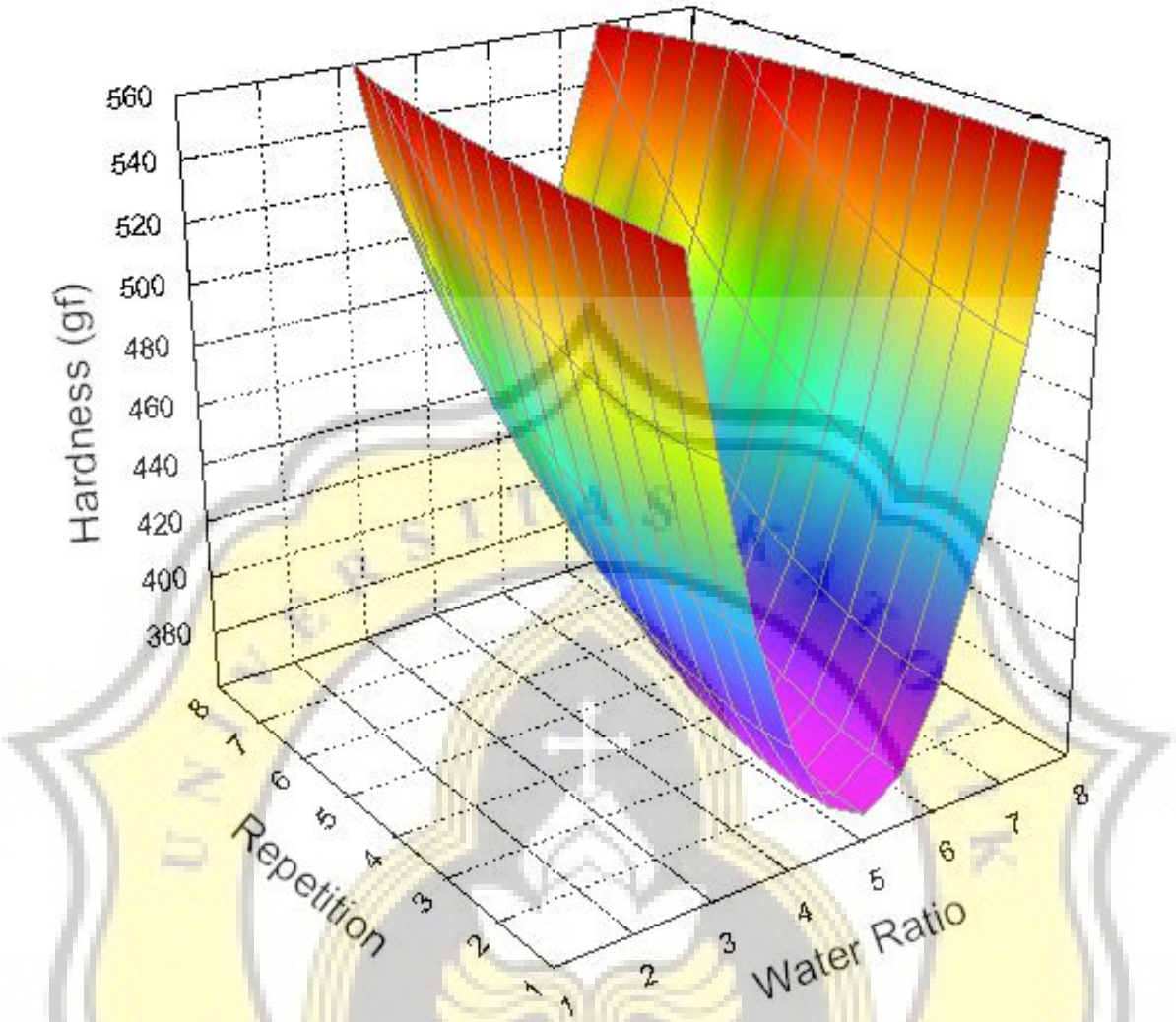

Figure 16. Surface Plot of Hardness at Different Water Ratio and Boiling Repetition

Figure 16 showed the surface plot of hardness at different water ratio and boiling repetition. The surface plot was a graphical representation of Y_5 regression equation based on Table 4. The surface plots take a convex shape. Minimum hardness can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).

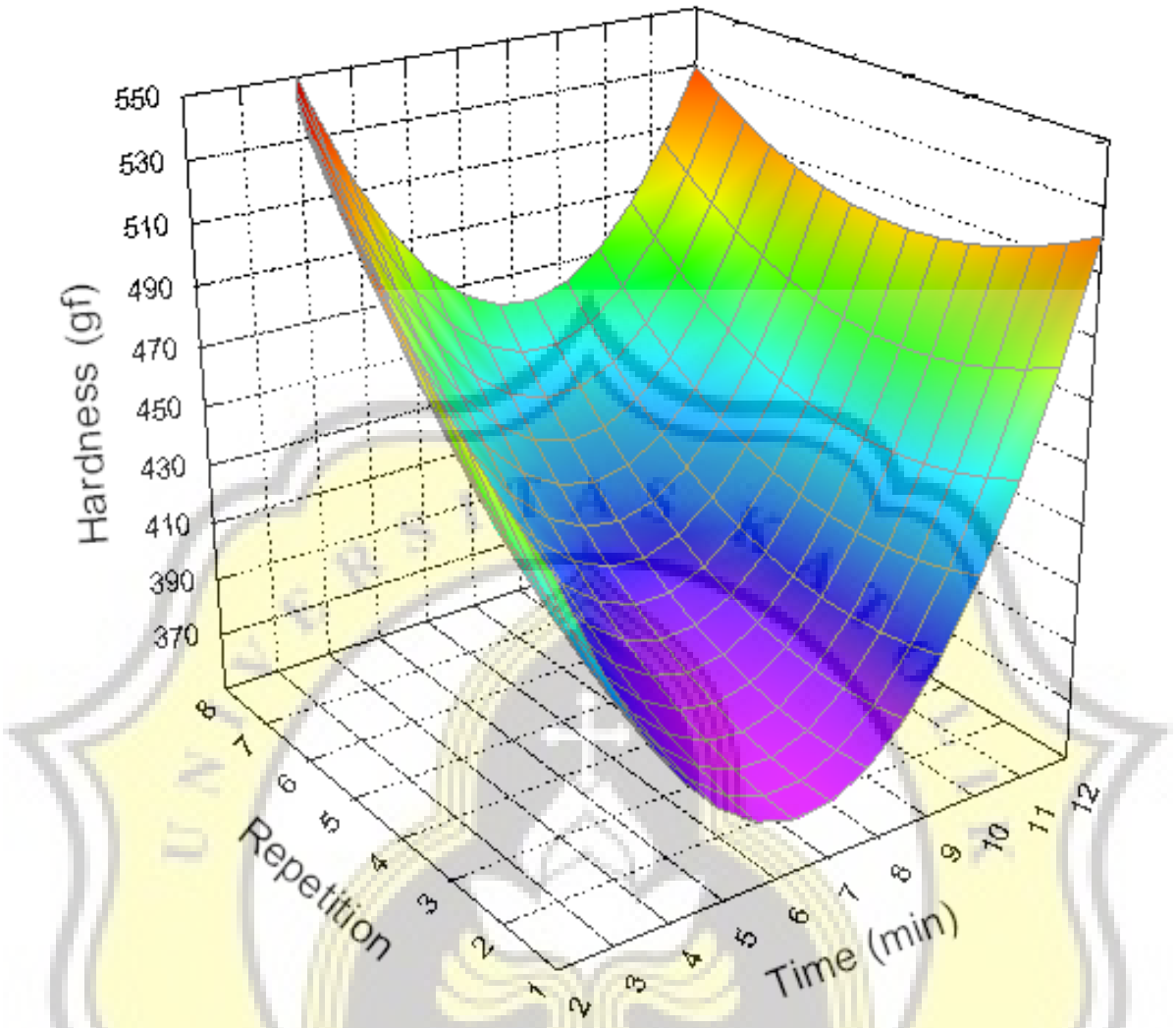

Figure 17. Surface Plot of Hardness at Different Boiling Time and Boiling Repetition

Figure 17 showed the surface plot of hardness at different boiling time and boiling repetition. The surface plot was a graphical representation of Y_5 regression equation based on Table 4. The surface plots take a convex shape. Minimum hardness can be obtained within the range of the study. This result was in accordance to the characteristic of the stationary points in the canonical analysis (Table 6).