Minimization of palm oil losses on sterilization process by optimization boiling pressure and boiling time

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Abstract. Optimization of boiling pressure and boiling time on palm oil processing was studied due to increasing oil palm capacity and quality by minimizing oil losses during sterilization process. We used 3 level of boiling pressure and 5 level of boiling time and analyzed of it’s effect to the amount of oil losses during the sterilization process. Design of Experiment Methods and Response Surface Methodology helped to see the effect of boiling pressure and boiling time to the amount of oil losses. From the study got a linear model that used to see and analyze the responses. From ANOVA test got the result that boiling time and boiling pressure significantly affected to the amount of oil losses, Optimize boiling time was 85-90 minute with boiling pressure 2.9 bar and average of amount of oil losses from triplicate data was 1.53%.

1. Introduction
CPO is a potential agroindustry product that important as a raw resources for another industry, such as biodiesel, cooking oil, margarine etc. Glycerin as side product from palm oil refinery also has important usage as solvent in food industry, pharmacy and skin care like soap, shampoo and tooth paste [2]. Its essential to produce crude palm oil with excellent quality and quantity, due to the fact that good quality refined oil cannot be produced from CPO with poor quality [4,5] So that need more research and study to increase capacity and quality of CPO.

Sterilization is the most importance process in palm oil mill [5]. Sterilization is importance to deactivate lipase enzyme, soften the fruit and facilitated fruit detachment (Cheng) Analysis regarding factor influences on response was performed using analysis of variance (ANOVA) and design of experiment, using Minitab 16 software.

2. Theory
A. Crude Palm Oil (CPO)
CPO is a product of processing palm oil plants which is currently an important agricultural commodity sector in Indonesia. CPO is a potential agroindustry product that important as a raw resources for another industry, such as biodiesel, cooking oil, margarine etc. Glycerin as side product from palm oil refinery also has important usage as solvent in food industry, pharmacy and skin care like soap, shampoo and tooth paste (Bari, S, et.al). At Riau Province, oil palm plantation reached 2,424,545 ha (BPS Riau), while in Indonesia reached 12 b ha. Kota Dumai as harbor city has important role in oil palm industry and its derivate product. There are 22 oil palm company in Kota Dumai, some of famous one are PT.Wilmar, PT. Sari Dumai Sejati, PT. Indo Palm, PT. Inti Benua, and others [2]
Palm oil processing are stage of refinery and fractionation. Refinery is palm oil processing from CPO to RBDPO (Refined Bleached Deodorized Palm Oil), including degumming, filtration, bleaching and deodorizing. Fractionation is process to separate liquid phase (olein) and solid phase (stearin).

B. Sterilization
Palm fruit came into palm oil mill running the process stage, start from weighting, sorting, sterilizing, and pressing till it become crude palm oil. Sterilization is one essential process, because quality dan quantity of oil palm depend on this stage process. Sterilization is importance to deactivate lipase enzyme, soften the fruit and facilitated fruit detachment [3]. Conventional palm oil mill carried out sterilization using saturated steam on 40 psi for 75-90 minutes [5]

3. Methods
This study focused on minimizing oil losses during sterilization process by optimizing the pressure and boiling time. In this case, data was collected from one palm oil factory in Dumai, Riau which has problems with their oil losses that above 2% (while they want it under 2%). This study used response surface methodology and design of experiment as factorial design $2^k$. According to Montgomery [6], there are some step on response surface methodology, i.e:

a. Create response surface design

Dua factor yang diuji (variable bebas) adalah boiling time (x1) dan pressure time (x2), variable tetapnya adalah amount of oil losses.

| Table 1. Code and Value |
|-------------------------|
| Level Code | -1 | 0 | 1 |
| x1 (time) | 85 | 95 | 105 |
| x2 (pressure) | 2.8 | 2.9 | 3 |

Penelitian dilakukan secara eksperiment dengan mengumpulkan data di stasiun perebusan di sebuah oil palm company in Dumai, Riau. Data collected was triplicate (3 times sample at one point) with different level of boiling time and pressure time. Untuk menghitung amount of oil losses, sample from steam condesat was analyze at laboratory.

b. Analysis of response surface design

Using Analysis of variance (ANOVA) the equation or model of design can be determined. General equation is as written in equation 1

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{22}X_{22} + e$$

where $\beta_0$ is constant parameter, $\beta_1$ and $\beta_2$ are linear parameter, $\beta_{11}$ and $\beta_{22}$ are square variable parameters, $\beta_{12}$ interaction parameter, and e is random error.

4. Results and Discussion

15 data were collected and run in laboratory to measure amount of oil losses in percentage of sample volume as shown in Table 1. As moderate level of pressure, we use 2.9 bar (40 psi) that use as conventional level of boiling pressure. By assuming that low pressure level need long duration of boiling time we use long interval of boiling time, from 85 min, 90 min, 95 min, 100 min and 105 min.

In this study, independent variable as factor are boiling time (x1) dan boiling pressure (x2), and as dependent variable (respon) is amount of oil losses.

| Table 2. Factor Level |
Run Time (min) Pressure (bar)
1  85  2.8
2  85  2.9
3  85  3
4  90  2.8
5  90  2.9
6  90  3
7  95  2.8
8  95  2.9
9  95  3
10 100  2.8
11 100  2.9
12 100  3
13 105  105
14 105  105
15 105  105

For calculation and determine design of experiment we used Minitab 16 software.

Table 3. Amount of Oil Losses (%)

| Run Order | X1     | X2     | y     |
|-----------|--------|--------|-------|
| 1         | 0.0000 | 0.0000 | 1.53  |
| 2         | 0.0000 | 0.0000 | 1.69  |
| 3         | 0.0000 | 0.0000 | 1.7   |
| 4         | 1.0000 | -1.0000| 1.97  |
| 5         | 1.0000 | 1.0000 | 2     |
| 6         | -1.0000| -1.0000| 2.19  |
| 7         | -1.0000| 1.0000 | 1.97  |
| 8         | 1.4142 | 0.0000 | 2.13  |
| 9         | 0.0000 | 0.0000 | 2.29  |
| 10        | 0.0000 | 0.0000 | 1.89  |
| 11        | 0.0000 | 1.4142 | 1.97  |
| 12        | 0.0000 | -1.4142| 3.45  |
| 13        | 0.0000 | 0.0000 | 2.33  |
| 14        | -1.4142| 0.0000 | 2.47  |

Table 4. Coefficient Parameter

| Term            | Effect | Coef  | SE Coef | T     | P    |
|-----------------|--------|-------|---------|-------|------|
| Constant        | 2.1520 | 0.07708| 27.92   | 0.000 |
| time            | 0.8413 | 0.4207 | 0.10900 | 3.86  | 0.003|
| pressure        | 0.4960 | 0.2480 | 0.09440 | 2.63  | 0.024|
| time*pressure   | 0.4120 | 0.2060 | 0.13350 | 1.54  | 0.151|

Design of experiment and response surface can be written as shown on equation 2.
y = 2.1520 + 0.4207x1 + 0.2480x2 + 0.2060x1x2

Analyze of regression model with store fit got that p<0.05 and R 60.2%. Regression model show that amount of oil losses influenced by boiling time, pressure time, but not much influenced by both of boiling time and boiling pressure, as shown in Figure 1.

Analysis of variance (ANOVA) need to find the effect of boiling time to the amount of oil losses dan effect of boiling pressure to the amount of oil losses. Using significant level of 95%, as result we got boiling time significantly affect to oil losses (p<0.05), so that boiling pressure vs oil losses (p < 0.05). But both those two variable hasn’t significantly affected to the amount of oil losses.

From surface plot and contour plot we can see that minimum oil losses had find at boiling pressure 2.9 bar and boiling time 85 min. So, it can answerres the problem of the company about suggested level of boiling pressure and boiling time. But we need to consider some others factor that also affected the amount of oil losses, like fruit ripeness, equipment and human factor. Need further study to minimize the oil losses and increasing quality and capacity of palm oil production.

5. Conclusion
This study aims to measure the optimize boiling time and pressure on sterilization process and get the result that minimum oil losses get at pressure 2.9 bar and boiling time 85 min. Tough its still need more further study to find another factor that also influenced to the amount of oil losses beside the boiling time and boiling temperature.

6. Acknowledgment
This study was supported by one of palm oil company in Dumai, Riau who want to be anonymous for any reason.

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