Analysis on quality improvement of used cooking oil with young pineapple (Ananas comosus) using Taguchi Method

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Abstract. Cristal small industry is one of the industries which focuses on processing the snake fruit chips in Sleman, Yogyakarta. To purify used cooking oil in this industry is using young pineapple as adsorbent. However, the industry did not know optimal condition of its adsorbent during the purification process. This research is aimed to determine the combination of optimum factor level of control factors that affect the quality of used cooking oil. Four control factors are as follow; processing time, temperature, atmospheric pressure and thickness of pineapple slice. The number of levels of each factor is three level. Based on the number and factor level used, the experimental design was prepared based on the orthogonal matrix L9 (3^4) as a tool in Taguchi method. Data analysis are conducted by using signal to noise ratio (SNR), factor effect, variance analysis, multiple performance characteristic and confirmation test. The results showed that the optimal condition for using young pineapple as adsorbent in used oil purification were temperature of cooking at 88°C, processing time for 70 minutes, atmospheric pressure of 72 mmHg and pineapple thickness of 4 mm.

Keywords. Quality improvement; used cooking oil; young pineapple; Taguchi Method

1. Introduction

Used cooking oil is cooking oil that is used for several frying process for producing snake chips at Cristal small industry at Sleman regency – Yogyakarta. This cooking oil led to undesirable condition such as producing brown color, foam during frying and unwanted flavor. Increasing the production correlated to oil consumption, so the used cooking oil increased too. Reuse the cooking oil would give added value [1].

Actually, the used cooking oil was found in many street vendors or frying process at industries. The dark color indicated that the quality of cooking oil decreased significantly, which was determined by peroxide value, color, saponification number and free fatty acid (FFA).

For purifying used cooking oil some adsorbents were applied, that could separate degradation reaction products from oil. One of them was young pineapple (Ananas comosus) that contained fiber for absorbing dirt and made the oil clearer [2].

This research was aimed to determine optimal condition for frying process with young pineapple as natural adsorbent by using Taguchi method. Therefore, the purified used cooking oil could be applied until certain condition that it was still appropriate for consumer safety.
2. Data and Method

The research was conducted at Cristal small industry and the laboratory of Food Engineering and Postharvest, laboratory of Chemistry and Biochemistry at Faculty of Agricultural Technology UGM. At Cristal industry all processing steps were conducted and observed, sample of used cooking oil was taken. Young pineapples as adsorbent were prepared for conducting frying process. The parameters of Free Fatty Acid (FFA), Saponification Value, Peroxide Value and Color (red and yellow).

Some processing factors were frying temperature, frying time, wedge pineapple thickness and atmospheric pressure. Taguchi method was applied for designing the research and it used 3 level for every factor [3][4]. By using orthogonal array L9 (3^4) it was determined that 9 times of experiments should be conducted. In Table 1 it showed the level of factors in the experiment.

| Table 1. Level of factors |
|---------------------------|
| Factor | 1 | 2 | 3 |
| A Temp (°C) | 85 | 88 | 90 |
| B Time (mnt) | 60 | 70 | 80 |
| C Pressure (cmHg) | 68 | 70 | 72 |
| D Thickness (mm) | 3 | 4 | 5 |

After determining levels and factors, orthogonal array was designed as follow:

| Table 2. Orthogonal array matrices |
|-----------------------------------|
| Experiment | A | B | C | D |
| I | 85 | 60 | 68 | 3 |
| II | 85 | 70 | 70 | 4 |
| III | 85 | 80 | 72 | 5 |
| IV | 88 | 60 | 70 | 5 |
| V | 88 | 70 | 72 | 3 |
| VI | 88 | 80 | 68 | 4 |
| VII | 90 | 60 | 72 | 4 |
| VIII | 90 | 70 | 68 | 5 |
| IX | 90 | 80 | 70 | 3 |

The research was conducted by following steps:

1. Five kilograms wedge young pineapple in certain thickness was prepared and then put in vacuum frying with 80 liter of cooking oil.
2. Adjustment of temperature, time, atmospheric pressure at vacuum frying, then the frying process was started and took certain minutes based on research parameter combination (table 2).
3. Results of experiments were measured on color, FFA, saponification value and Peroxide value.
3. Result and Discussion

The results were depicted in Table 3 and Table 4 respectively.

**Table 3.** Experiment results

| No. | Red-color | Yellow-color | FFA (%) |
|-----|-----------|--------------|---------|
| 1   | 9.0       | 60           | 0.320   |
| 2   | 10        | 60.5         | 0.371   |
| 3   | 8.5       | 58.5         | 0.499   |
| 4   | 9         | 56.75        | 0.230   |
| 5   | 9.5       | 56.25        | 0.243   |
| 6   | 8.5       | 57.5         | 0.243   |
| 7   | 10.5      | 58           | 0.269   |
| 8   | 9.75      | 55.5         | 0.320   |
| 9   | 8.0       | 58.5         | 0.538   |

**Table 4.** Experiment results

| No. | Saponification Value (mg KOH) | Peroxide Value (meq O₂/kg) |
|-----|--------------------------------|-----------------------------|
| 1   | 195.806                        | 44                          |
| 2   | 198.611                        | 19                          |
| 3   | 202.258                        | 15                          |
| 4   | 201.136                        | 19                          |
| 5   | 195.245                        | 22                          |
| 6   | 196.367                        | 15.5                        |
| 7   | 202.258                        | 17.5                        |
| 8   | 182.621                        | 21                          |
| 9   | 194.403                        | 22.5                        |

Based on Table 3 and Table 4 it was indicated that some parameters decreased and wedge of young pineapple had good function as adsorbent.

The results were analyzed by multiple performance characteristics, where all quality characteristics were gathered. First step was calculated loss function value and normalization for unifying the data, because each quality characteristics had different value but the effect to the process was equal. The quality characteristics had equal percentage 25% each. The results of total loss function and Signal Noise Ratio (SNR) were showed at Table 5.

**Table 5. Multi response SNR**

| No. | Total Loss Function | SNR |
|-----|---------------------|-----|
| 1   | 1.589               | -2.011 |
| 2   | 0.975               | 0.109  |
| 3   | 1.121               | -0.494 |
| 4   | 0.770               | 1.133  |
| 5   | 0.844               | 0.737  |
| 6   | 0.705               | 1.516  |
| 7   | 0.851               | 0.700  |
| 8   | 0.878               | 0.565  |
| 9   | 1.259               | -1.002 |
SNR is a quality indicator in product, higher SNR value led to better product quality. The factors that gave most effective effect on product were determined in following table 6.

| Level  | A     | B     | C     | D     |
|--------|-------|-------|-------|-------|
| Level 1| -0.799| -0.059| 0.023 | -0.759|
| Level 2| 1.129 | 0.471 | 0.080 | 0.775 |
| Level 3| 0.088 | 0.430 | 0.314 | 0.401 |
| Difference| 1.928 | 0.530 | 0.291 | 1.534 |
| Ranking | 1     | 3     | 4     | 2     |

Combination of each factors was compiled by selected highest values that affected on cooking oil purification. The combination was frying temperature 88°C, time 70 minutes, atmospheric pressure 72 cmHg and wedge young pineapple thickness 4 mm.

This combination was calculated by analysis variances (ANOVA) for determining contribution percentage of each factors optimally. The result was depicted on table 7.

| Source   | SQ  | V  | MS  | p          |
|----------|-----|----|-----|------------|
| Temp.    | 5.586 | 2 | 2.793 | 55.487%    |
| Time     | 0.501 | 2 | 0.250 | 4.973%     |
| Pressure | 0.143 | 2 | 0.073 | 1.419%     |
| Thickness| 3.838 | 2 | 1.919 | 38.121%    |
| Error    | 0.00 | - | -    | -          |
| Total    | -   | - | -    | 100%       |

Based on table 7 it could be divided into frying temperature contributed 55.487% on optimal condition this attempt for improving quality of used cooking oil by adding wedge young pineapple during the frying process. Thickness of wedge pineapple gave 33.122%, frying time was 4.973% and atmospheric pressure was 1.419% respectively.

The results of improving quality of used cooking oil could be seen at table 8.

| Parameters       | Before | After |
|------------------|--------|-------|
| FFA (%)          | 1.16   | 1.04  |
| Peroxide Value (meq O₂/kg) | 28     | 24.67 |
| Saponification Value (mg KOH) | 221.57 | 211.87 |
| Color (Red – Yellow) | 25 – 64 | 23 - 60 |

All quality parameters could be decreased and probably the oil could be used 1-2 times before it had to change with fresh cooking oil.

4. Conclusions
The optimal condition for purifying used cooking oil at Cristal small industry could be achieved, namely frying temperature 88°C, time 70 minutes, atmospheric pressure 72 cmHg and wedge young pineapple thickness 4 mm.
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