The influence of steaming and a ratio of grated coconut to water on the yield and quality of virgin coconut oil

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Abstract. The quality of Virgin Coconut Oil (VCO) is determined by the quality of coconut milk. High quality of coconut milk can be obtained by proper handling of grated coconut as raw material. When coconut was shredded, the lipases are exposed which can hydrolyse the oil resulting free fatty acid (FFA). Steaming is a technique to inactivate lipases. In addition, a ratio of grated coconut to water and steaming duration are important factor to the VCO extraction. Therefore, this study aimed to obtain the best combination of steaming duration and suitable ratio of grated coconut to water in order to produce high quality VCO. The research design was Factorial Randomized Block Design consisted of 2 factors: steaming duration (5; 10; and 15 minutes) and grated coconut to water ratio (1:0; 1:1; 1:2; 1:3; and 1:4 w/v), each treatment was repeated twice. Parameters analyzed were FFA, moisture content, and yield values. The result showed that the best treatment was a treatment with 15 minutes steaming of grated coconut and 1:4 ratio of grated coconut to water. The best treatment VCO had characteristic as follows: FFA 0.054 %, moisture content 0.129 % and yield 17.563 %.

1. Introduction
Coconut has been widely used and all parts of the coconut are highly beneficial toward human life [1]. One of coconut’s product is Virgin Coconut Oil (VCO) extracted from old coconut flesh by pressing with or without water addition. VCO contains 93% of long and short chain saturated fatty acid consisted of lauric acid (50.33%); capric acid (10.25%); caproic acid (14.23%); palmitic acid (4.92%); and myristic acid (12.91%) [2].

One of essential factors to be considered in VCO production is good handling of coconut since the quality of the oil produced is determined by the quality of the coconut milk. Grating the coconut disintegrates the cell structure so that lipase can digest oil [3] which leads to premature rancidity. One traditional technique to prevent the deterioration reaction is steaming.

Steaming is one of food processing technique by putting food on vaporizing water in a closed chamber [4]. This process can lengthen the grated coconut shelf life prior to the next process by lipase heat inactivation. However, the longer the steaming causes the damage to the nutritional compounds of the grated coconut.

Besides steaming, extracting the coconut milk using certain grated coconut to water ratio also plays essential role in producing high yield and good quality coconut milk. Therefore, this study aimed to
find the best combination of steaming duration and grated coconut to water ratio in order to produce high quality VCO.

2. Materials and Methods

2.1. Materials and Instruments
Coconut Dalam variety was obtained from Malang district. Materials used in this research were water, plastic bags, 0.05 M NaOH (PA), phenolphthalein indicator (PA), ethanol 95%, aquadest, and filter paper (Whatman 7).

Instruments used on this study were beaker glass (Iwaki), blender (Philips HR2116 - capacity 2 L), electric coconut grater, hotplate (Labinco), steaming apparatus (Jawa - diameter 30 cm), pipette, thermometer, pressing machine, freezer (Samsung), digital scale (Camry), funnel (Herma – 75 mm), and stopwatch.

2.2 Method
This research used Factorial Randomized Block Design consisted of 2 factors: steaming duration (factor A) and a ratio of grated coconut and water (factor B). Factor A was 5, 10, and 15 minutes, whereas Factor B was ratio of grated coconut (kg) to water (L) 1:0; 1:1; 1:2; 1:3; and 1:4. Therefore, there were 15 combinations of treatment, two repetitions for each treatment. Therefore, there were 30 experimental units.

Eleven to twelve months old coconut was obtained from Mergan traditional market supplied from Ngajum, Malang district. First step in producing VCO was separating the coconut flesh from the shell, grating and steaming under 55°C for 5; 10; and 15 minutes. The next step was extracting coconut milk based on the grated coconut to water ratio 1:0; 1:1; 1:2; 1:3; and 1:4 then squeezing to extract milk which then left to stand for 2 hours in order to separate cream from the emulsion. The cream was extracted and frozen for 24 hours. Frozen cream was crushed using blender for 20 minutes until the compact cream was formed. The compact cream was heated until 50°C to separate oil, water, and residue. Finally, the mixture was filtered to obtain VCO. The VCO was analyzed for FFA, moisture, and yield.

2.3 Statistical Analysis
The data was analyzed using Analysis of Variance (ANOVA) test to observe whether there was any major influences due to the agreed factors. If there was any, data was put into 5% of confidence interval Duncan’s Multiple Range Test (DMRT). Following the DMRT test, the best treatment was determined and concluded.

3. Results and Discussion

3.1 Free Fatty Acid (FFA)
Steaming duration and a ratio of grated coconut and water affects value of FFA ($a=0.05$). The highest FFA content was at the combination of 5 minutes steaming and 1:4 grated coconut to water ratio which was 0.068 %. While, the lowest one was at the combination of 15 minutes steaming and 1:0 grated coconut to water ratio which was 0.036 %. This has occurred because oil was hydrolyzed by water and lipase produced FFA, the higher FFA content means the lower the quality of VCO oil [5]. However, the FFA value from those treatments met the SNI 7381:2008 standard of maximum FFA of 0.2 %.
Table 1. The Effect of Steaming Duration on VCO’s FFA.

| Steaming Duration (minutes) | Average FFA (%) |
|-----------------------------|-----------------|
| 5                           | 0.059 ± 4.240 x 10^-6c |
| 10                          | 0.054 ± 3.210 x 10^-6b |
| 15                          | 0.045± 5.270 x 10^-6a |

Note: Numbers followed by a different notation indicates the difference between treatments (DMRT 5%: 2.766 x 10^-3)

As shown on Table 1, a 5-minute steaming generates the highest percentage of FFA which is 0.059% whilst the lowest one is in a 15-minute steaming which is 0.045%. The longer steaming duration, VCO’s FFA decreases. Steaming for 15 minutes is over than the maximum time required to inactivate naturally occurring of lipase which hydrolyses triglyceride producing FFA and glycerol. Steaming can inactivate the enzyme which is responsible for colour, taste, and nutrients changes [6].

Table 2. The Effect of Grated Coconut to Water Ratio on VCO’s FFA.

| Grated Coconut to Water Ratio | Average FFA (%) |
|-------------------------------|-----------------|
| 1:0                           | 0.044± 5.320 x 10^-6a |
| 1:1                           | 0.049± 7.150 x 10^-6b |
| 1:2                           | 0.055± 5.100 x 10^-6c |
| 1:3                           | 0.056±3.040 x 10^-6d |
| 1:4                           | 0.061± 4.800 x 10^-6e |

Note: Numbers that followed by a different letter indicates the presence of considerable difference (DMRT 5%: 2.766 x 10^-3)

Table 2 shows a ratio1:4 generates the highest percentage of FFA which is 0.061% whilst the lowest one was in a ratio1:0 ratio which is 0.044%. The high content of FFA was caused by the presence of excess water that facilitated oil hydrolysis producing glycerol and FFA. Oil hydrolysis is catalyzed by heat, moisture, acid, and catalyist of enzyme or synthetic catalyst. High amount of water used in coconut milk extraction can accelerate oil hydrolysis thus generating more FFA [7].

3.2 Moisture content

Steaming duration and grated coconut to water ratio had considerably affected VCO’s moisture(a=0.05). The highest moisture content was on VCO obtained from the treatment of 5 minutes steaming and 1:4 grated coconut to water ratio which was 0.183%. On the other hand, the lowest moisture content was on VCO obtained from the treatment of 15 minutes steaming and 1:0 grated coconut to water ratio which was 0.088%. This has occurred due to water vaporization during steaming and the amount of water used in coconut milk extraction also affects the final products’ moisture, moist oil means low quality oil. Moist in the oil tends to shorter the shelf life [5]. However, these two moisture contents met the SNI (Standard National Indonesia) 7381:2008 standard as tolerated maximum of 0.2 %.

Table 3. The effect of steaming duration toward VCO’s moisture content.

| Steaming Duration (minutes) | Average FFA (%) |
|-----------------------------|-----------------|
| 5                           | 0.124 ± 1.212 x 10^-6a |
| 10                          | 0.114 ± 9.232 x 10^-6b |
| 15                          | 0.104± 2.236 x 10^-5a |

Note: Numbers that followed by a different letter indicates the presence of considerable difference (DMRT 5%:8.962 x 10^-5)

Table 3 shows a 5-minute steaming of grated coconut generates the highest percentage of FFA which is 0.124% whilst the lowest one is found in 15 minutes steaming which was 0.104%. The longer steaming duration, the lower the VCO’s moisture contents. This observation was supported by the fact
that process time and temperature affected the ingredient’s moisture [8]. The longer steaming time and the higher the temperature, the more water is evaporated.

Table 4: The effect of grated coconut to water ratio on VCO’s moisture content

| Ratio of Grated Coconut to Water | Average Moisture Content (%) |
|---------------------------------|------------------------------|
| 1:0                             | 0.093± 4.710 x10^-8b         |
| 1:1                             | 0.102 ± 3.000 x10^-8b        |
| 1:2                             | 0.103± 7.000 x10^-8c         |
| 1:3                             | 0.114± 2.660 x10^-5d         |
| 1:4                             | 0.160 ± 7.500 x10^-5e        |

Note: Numbers that followed by a different letter indicates the presence of considerable difference (DMRT 5%; 8.962 x 10^-5)

Table 4 shows that at a ratio of 1:4, VCO has the highest of moisture content of 0.160% whilst the lowest one is in VCO obtained from treatment at a ratio of 1:0 of 0.093%. The more water used in coconut milk extraction, the higher the VCO’s moisture content. This result might be caused by the type of emulsion of coconut milk (O/W) which contains high water. More oil entrapped in the water increases the VCO’s yield. Emulsion type of O/W has higher moisture compared to W/O emulsion [9].

3.3 Yield

Interaction between steaming duration and grated coconut to water ratio has considerably affected VCO’s yield (α=0.05). The highest yield was at the combination of 15 minutes steaming and a ratio of 1:4 grated coconut to water which was 17.563%. Whilst the lowest one was at the combination of 5 minutes steaming and a ratio of 1:0 grated coconut to water which was 5.562%.

Table 5: Duncan test result for VCO’s yield.

| Treatment | Average Yield (%) |
|-----------|-------------------|
| 5         |                   |
| 1:0       | 5.562^d           |
| 1:1       | 9.471^g           |
| 1:2       | 12.689^f          |
| 1:3       | 12.880^f          |
| 1:4       | 13.723^e          |
| 1:0       | 7.161^h           |
| 1:1       | 12.138^f          |
| 10        |                   |
| 1:2       | 14.896^d          |
| 1:3       | 16.100^c          |
| 1:4       | 17.204^a          |
| 1:0       | 7.803^g           |
| 1:1       | 12.591^f          |
| 1:2       | 14.980^d          |
| 15 minutes|                   |
| 1:3       | 16.818^b          |
| 1:4       | 17.563^a          |

Note: Same letter notation indicates the presence of inconsiderable difference on DMRT test (α=0.05); ^) the best treatment

Differences between steaming duration and grated coconut to water ratio as shown on Table 5. These two factors have affected VCO’s yield significantly. The result showed that 5 minutes steaming and 1:0 ratio, whilst the highest one in VCO obtained from the combination between 15 minutes of steaming and a ratio of 1:4 which was 17.563%. Steaming causes grated coconut’s pores to open thus coconut milk can be extracted easily. In addition, high amount of water in the steam can also help in extracting the milk. The high amount of coconut milk results a lot of cream to be produced. Coconut
milk extraction efficiency is affected by temperature of extraction and the amount of water [10]. This statement is supported by other studies that the suitable ratio of coconut milk and water in order to produce VCO with 20 % yield was 1:2 [11].

3.4 Determination the best treatment

The results showed that the higher the yield, the lower the oil qualities. The highest yield was obtained from oil extracted with steaming for 15 minutes and a ratio of 1:4 of grated coconut and water. The best quality of the oil was obtained from oil extracted at steaming for 15 minutes and at a ratio of 1:0 of grated coconut and water. The SNI 7381:2008 of VCO standard requires that moisture content and FFA of VCO are a maximum of 0.2%. However, the lowest quality VCO obtained from this research still met the SNI 7381:2008. The best result was determined in accordance with SNI’s standards of VCO that had characteristic as follows: 0.054 % of FFA, 0.129 % of moisture content, and 17.563 % of yield.

4. Conclusion

The steaming of grated coconut and a ratio of grated coconut to water affected the VCO’s yield, FFA and water content of VCO. The best treatment of the VCO was obtained from the steaming for 15 minutes and a ratio 1:4 of grated coconut to water. It has characteristic as follows: 0.054 % of FFA, 0.129 % of moisture content, and 17.563 % of yield.

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