The quality assessment on fermented virgin coconut oil treated under microwave heating

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Abstract. The study aimed to evaluate the quality of fermented virgin coconut oil (FVCO) treated under microwave heating. The FVCO was produced by local farmer from Aceh Besar District, the province of Aceh, Indonesia. A home microwave oven Samsung ME731K at frequency of 2,450MHz was used to heat 100ml of FVCO for 10 minutes. The experimental was designed by the variation of microwave power at 4 levels i.e. 0, 300, 450, and 600W. The parameters assessed were temperature, moisture, free fatty acid (FFA), and peroxide value (PV). The data was analysed by using analysis of variance (ANOVA). Results showed that the quality of FVCO still could not be improved yet where most of parameters observed did not meet the quality standard of VCO. However, the challenge of using microwave heating to improve the FVCO quality is quite big since the treatment had significantly influenced the FVCO temperature. Further study is highly recommended to treat the FVCO under microwave heating with the improvement in the procedure of observation.

1. Introduction
Fermented virgin coconut oil (FVCO) is produced by Acehnese since long time ago. The procedure is believed to have zero waste [1]. The process was healthy without high temperature and chemical addition [2]. However, the FVCO quality does not meet the quality standard for VCO influenced by no standard in processing procedure, fermentation method and drying technology [3]. The production of FVCO is still run by small scale industries with low technology adaptation. Due to low quality of FVCO, today the primary products expected from this traditional process is also changed to pliek-u, not oil anymore. In the past, pliek-u, the fermented coconut, was assumed as the waste product from FVCO processing. Meanwhile, pliek-u has special taste and by using this product, the Acehnese can cook such delicious soup called “Kuah Pliek”. The tradition of FVCO processing actually should be maintained as a tool to improve the local people welfare and health [4]. Recent study also showed that pliek-u could be used as functional food against bacterial [5]; and the VCO could inhibit the development of Candida albicans [6]. Therefore, further studies about FVCO are expected to bring this local wisdom in modern sense as well as to conserve the tradition.

Heating is used in oil processing and there are many ways to generate heating. The fastest way to generate heating is by using the electromagnetic wave such as microwave and radio frequency because it works volumetrically. The advantages of using microwave are the rapid, uniform, and selective heating involving no direct contact between the microwave source and the heating material [7]. The interaction between electromagnetic field and chemical components of foods as molecular friction and...
excitation increase the temperature [8]. The use of microwave heating is expected to prevent the degradation as well as to minimize the energy consumption [9]. There is a challenge to apply high temperature in short time to the FVCO by using the microwave heating. Previous study had been conducted to evaluate the FVCO quality after 40-60s microwave heating of 60ml FVCO at power of 800W [4] and after 60s microwave heating at FVCO volume of 20 to 60ml [10]; both studies had recommended the further study to evaluate the challenges of using microwave energy to improve the FVCO quality.

The use of microwave heating to oil palm fresh fruit could interrupt the production of free fatty acid (FFA) [11]. Microwave has potential to be used as an alternative way in the demulsification process of water in oil [12]. The FFA and water contents are parameters quality of VCO determined by the Codex Alimentarius and Asian and Pacific Coconut Community (APCC) [13] and Indonesian standard of SNI 7381:2008 [14]. Since the quality of VCO is low with high content of FFA [3], the use of microwave is expected to improve its quality. The aim of this study was to evaluate the influence of power after 10minutes microwave heating to the FVCO quality.

2. Methodology

2.1. Materials and methods

The study was conducted at Laboratory of Postharvest Technology, Department of Agricultural Engineering, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia from June to July, 2020. The main instruments used was microwave oven, Samsung ME731K at frequency of 2,450MHz with 200mm turn-table diameter.

The FVCO was collected from a local farmer in Aceh Besar district. About 100ml of FVCO was weight and put into flat bottom flask glass. The FVCO was heated by using microwave with the variation of power 300, 450, and 600W for 10 minutes at 3 replications. Before and after the treatment, the temperature of FVCO was measured by using infrared thermometer. Then, the FVCO was cooled in desiccator and then stored in the plastic bottle. Between each unit experiment, the temperature of microwave chamber was cooled until it reached the room temperature by using an electric fan.

The parameters observed were temperature, moisture, free fatty acid (FFA), and peroxide value (PV). The data were analysed by using one-way analysis of variance (ANOVA).

2.2. Procedure analysis

The moisture content was determined according to air oven methods [14]; the empty weighing bottle was dried in the oven at 105°C for 1 hour, transferred to desiccator to cooldown the temperature for 30 minutes, and weighed; the FVCO sample about 5 g was put in the weighing bottle, weighed (m1) and placed inside the oven; then it was dried for 1 hour at the temperature of 105 °C; the weighing bottle with dried sample was cooled into desiccator for 30 minutes; the procedure was repeated until the weight (m2) was constant; finally, the moisture was determined as:

$$KA(\%) = \frac{m_1-m_2}{m_1} \times 100\% \quad .................................................................(1)$$

The FFA content was determined by using AOCS Official Method Ca 5a-71 1993 [14]. About 30g of FVCO (w) were transferred to Erlenmeyer 250ml, added by 50ml ethanol 90%, and titrated by indicator phenolphthalein and standard alkali NaOH 0.1N until the first permanent pink color appears for 15s. The volume of NaOH used for titration was noted (V). The FFA was measured as lauric acid with molecule weight of 200. The FFA content was calculated as:

$$FFA(\%) = \frac{200 \times V \times N}{10 \times w} \quad .................................................................(2)$$
To determine the PV [14], about 5g FVCO (w) was transferred to Erlenmeyer 300ml and mixed by 10ml chloroform by stirring the Erlenmeyer. About 15ml acetic acid and 1ml saturated potassium iodide was dissolved with the oil sample in the Erlenmeyer, closed and mixed for 5 minutes in the darkness at temperature 15-25°C. Then 75ml distillated water was added and mixed strongly. The solution was titrated by sodium thiosulfate 0.02N and starch. The volume of sodium thiosulfate used for titration the blanko was noted as \( V_0 \), while the volume of sodium thiosulfate used for titration the FVCO was noted as \( V_1 \). The PV was determined as:

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PV (\text{meq/kg}) = \frac{(V_1-V_0) \times N}{w} \times 1000
\]

.................................................................(3)

3. Results and discussion

3.1. The Increase Temperature of FVCO

After microwave heating, the increasing temperature of FVCO was shown significantly (Figure 1). The average initial temperature was about 30.2°C as the room temperature appeared. The microwave heating at power 300W had increased the FVCO temperature to 112.9°C; as the power was increased the FVCO temperature was also risen; at power 600W the FVCO temperature was 161.9°C. However, the standard deviation of FVCO temperatures were also growing as the power was increased. This high standard deviation values of FVCO temperature had been caused by the uniformity of temperature which was the characteristic of microwave heating [15].

![Figure 1](image-url)  

**Figure 1.** The temperature of FVCO before and after microwave heating at different power.

Previous study showed that after 1min microwave heating at power of 800W, the FVCO temperature reach about 87°C [4]. However, the volume of oil in this study was 100ml, whereas the volume of oil in the previous study was approximately 60ml. It was believed that the volume of oil had influenced the oil temperature [10]; moreover, the sample size strongly influenced the behavior of microwave heating [16]. The other studies showed that the temperature of oil after 10minutes microwave heating at power 800W was about 200°C [8]; whereas the highest temperature of FVCO in this study was about 161.9°C. These difference was caused by lower power applied in this study i.e. from 300 to 600W.
The analysis of variance (ANOVA) showed the variation of power had influenced the FVCO temperature significantly. However, the further test by using Duncan had shown that the use of 300W power had no significant difference from the use of 450W power.

3.2. The Effect of Microwave Heating to the Moisture Content of FVCO

The initial moisture content of FVCO was 0.3633%. It can be shown from Figure 2 that the changes of FVCO moisture after microwave heating was irregularly. Interestingly, the FVCO moisture after microwave heating tends to increase. However, in comparison to previous study, the increasing values of FVCO moisture was higher to about 0.74 and 0.91% [4]; while the moisture of FVCO after microwave heating in this study ranged from 0.47 to 0.56%. High standard deviation of FVCO moisture described that the data among replications had high variation; it was indicated that there was external factor occurred during experiment to cause the error.

![Figure 2](image-url)

**Figure 2.** The moisture of FVCO before and after microwave heating at different power.

As the temperature after microwave heating had significantly increased, the improvement of FVCO moisture after microwave treatment was strange. In contrast to this, the moisture of crude palm oil had decreased under microwave heating between 10 and 18 minutes because of the utilization of water to absorb the microwave irradiation [17]. In this study, the duration of microwave heating is about 10 minutes. Therefore, it explained that the longer time more than 10 minutes is important to reduce the moisture content of FVCO. In comparison to the previous study [10], the results of this study was corrected by cooling process of FVCO after treatment in the desiccator. Nevertheless, the moisture of FVCO did not meet the SNI standard yet since the maximum moisture allowed in FVCO was 0.2%.

According to ANOVA analysis, the power of microwave heating between 300 to 600W for 10 minutes on 100ml FVCO did not influence the moisture of FVCO. As it was shown already in Figure 2, the high standard deviation of moisture among replications could cause the results. The same phenomena were indicated in previous studies [4]. Considering this fact, the experiment should be repeated to assure this results. The procedure of microwave heating should be improved by heating FVCO in large opened bowl and by stirring the oil before heating.

3.3. The Effect of Microwave Heating to Free Fatty Acid of FVCO

The free fatty acid (FFA) of FVCO before microwave heating was 6.35%. After microwave heating, the FFA of FVCO were slightly decreased. At all experiments, the FFA of FVCO were still above 6%
(Figure 3). However, the FFA of FVCO in this experiment were lower than the FFA of FVCO after microwave heating at power of 800W and volume of 40ml for 40 to 60s [4]. The FFA of FVCO could reduce to about 5.75% after microwave heating at power of 800W and volume of 20ml for 60s [10]. The reduction of FFA in red palm oil correlated to inactivation of enzyme lipase after using microwave heating at power of 800W for 14 minutes [17]. The microwave heating by using the power of 90W for 40 minutes on palm fruit was the most effective way to control the FFA of palm oil [11].

According to ANOVA analysis, the power of microwave heating between 300 to 600W for 10 minutes on 100ml FVCO did not influence the FFA of FVCO. The FFA of FVCO did not meet all standards; the Codex Alimentarius, the APCC, and Indonesian National standard (SNI). The maximum FFA in VCO was 0%, 0.5%, and 0.2% required by Codex Alimentarius, the APCC, and SNI standard, respectively.

![Figure 3](image.png)

**Figure 3.** The FFA of FVCO before and after microwave heating at different power.

### 3.4. The Effect of Microwave Heating to Peroxide Value of FVCO

The initial peroxide value (PV) of FVCO was 3.2 meq/kg. After microwave heating at power 300W, the PV of FVCO was reduced to 2.5 meq/kg, but the PV had increased again to 2.8 and 4.9 meq/kg after microwave heating at power 450 and 600W, respectively (Figure 4). These irregular changes was difficult to be explained, but the big standard variation of PV had described that there was high variation of PV among the replications. The biggest data variation occurred at the untreated FVCO; it was about 2.8 meq/kg. Regarding to this issue, the ANOVA showed that there is no influence of microwave power to the PV of FVCO. However, according to the other study, the temperature of 70°C for 60minutes was best compared to the temperature of 50, 60, 80, and 90°C in the clarification process of used cooking oil [18].

According to the Codex Alimentarius, the maximum PV allowed for VCO oil is 15 meq/kg; therefore, the PV of FVCO had met the standard. However, the characteristic of coconut oil as the most oxidatively stable oil could be the other reason of increasing values of PV as the microwave power was risen [13]; the higher the FVCO temperature the higher the PV of FVCO [4,10]. The other factors such as the duration of microwave heating and the volume of oil heated would also affect the results.
4. Conclusions
In conclusion, the study found that the quality of FVCO still could not be improved under the variation of microwave power between 300 to 600W for 10 minutes microwave heating at volume of 100ml. However, due to significant influence of the microwave heating to temperature increasing, the challenge of using microwave heating to improve the FVCO quality is quite big. Further study is highly recommended to heat the FVCO by using microwave heating with important improvement in the procedure such as the stirring process of oil before heating, and the use of big opening bowl during heating to let the water vapour moves fluently.

![Figure 4. The PV of FVCO before and after microwave heating at different power](image)

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