Improving fermented virgin coconut oil quality by using microwave heating

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Abstract. The study aimed to improve the quality of fermented virgin coconut oil (FVCO) under microwave heating. The FVCO was collected from a local farmer in Aceh Besar District. A microwave oven at frequency of 2,450MHz and power of 800W was used to heat 40ml FVCO in a ceramic bowl by the variation heating time i.e. 40, 50, and 60s. The parameters observed were temperature, moisture content, free fatty acid (FFA), and peroxide value. Results showed that the quality of FVCO did not meet the quality standards such as Codex Alimentarius, Asian and Pacific Coconut Community (APCC), and the Indonesian National Standard (SNI). However, the study found that the microwave heating time had influenced the FVCO temperature significantly where the final temperature had reached 71-87°C. However, there were no significant influences of microwave heating time to the moisture, FFA, and peroxide value of FVCO. It could be caused by the short time used in this experiment; therefore, it is suggested to extend the heating time for further study.

1. Introduction

The Acehnese society has produced virgin coconut oil by using the fermentation method since a long time ago. This coconut oil fermentation method is highly efficient with zero waste [1]. The process results three products i.e. fermented virgin coconut oil (FVCO, called as simplah oil), cooking oil (called as pliek oil), and pliek-u. Presently, the quality of FVCO does not meet the quality standard influenced by no processing standard, different index maturity of coconut as well as fermentation process and the drying method applied [2]. Therefore, it is proposed to maintain the tradition and oil quality as a tool to improve the people’s welfare and health.

Microwave heating is known as the most attractive heating methods used in food preparation, commonly applied in households and especially in restaurants due to its high speed and convenience [3]. The mechanism of microwave heating is the interaction of an electromagnetic field with chemical components of foods, due to molecular friction and excitation; and it generates the volumetric heating so that the application of microwave energy reduces speed and time when it is compared with the conventional heating method [4].

Heating is a common method to be used to improve the oil quality. If it is compared to the other thermal method, the use of microwave heating prevents the degradation of the products and needs a shorter reaction time together with a lower energy consumption [5]. The dielectric properties of the material will influence the microwave energy absorption while these dielectric properties are influenced by many factors such as frequency, temperature, moisture content and density of the products [6].
High content of free fatty acid (FFA) is a common problem in crude palm oil [7,8], olive oil [9,10], canola oil [3], and corn and soybean oil [4]. Microwave heating could interrupt the free fatty acid (FFA) production at the optimum temperature of fruit mesocarp about 50°C [7]. It was reported also that microwave heating affected the quality of oil differently according to its composition [4].

The standard quality for VCO is determined by 2 organizations: the Codex Alimentarius, and Asian and Pacific Coconut Community (APCC) [11]. Moreover, the Indonesian standard for VCO quality is SNI 7381:2008. The objective of this study is to improve the quality of fermented virgin coconut oil (FVCO) treated under microwave heating by the variation of heating time.

2. Material and Methods

The study took place at the Laboratory of Postharvest Technology, Department of Agricultural Engineering, Faculty of Agriculture, University of Syiah Kuala, Banda Aceh, Indonesia, in June 2019. The microwave oven, Samsung ME731K 800W with frequency of 2.450MHz which has the dimension of 489mm x 275mm x 341mm with 200mm turn-table diameter, was used for the experiment. The fermented virgin coconut oil (FVCO) was collected from a local farmer in Aceh Besar District.

A 40ml FVCO was prepared on a ceramic bowl. The experiments were carried out by heating FVCO with the microwave oven with the variation of the exposure times 40, 50, and 60s, at three replications. FVCO temperature was determined immediately after the microwave heating by using an infrared thermometer. Then, FVCO were cooled at room temperature for further analysis. The parameters observed were moisture content, free fatty acid (FFA) content, and peroxide value. The data was analyzed by using one-way ANOVA.

Moisture content determination was conducted according to air oven method (FAO, 1981)[12]. The empty porcelain dish was dried in the oven at 105°C for 3 hours, transferred to desiccator to cool down the temperature, and weighed. The FVCO sample about 5 g was put in the dish, weighed and placed inside the oven. Then it was dried for 3 hours at the temperature of 105 °C. The porcelain dish with dried sample was cooled into desiccator. Finally, the dishes were weighed to determine water content.

FFA test was measured according to the AOCS Official Method Ca 5a-40. The FVCO sample of 7.05±0.05 g was dissolved in 75 ml ethanol 95% and was titrated with the standard solution of sodium hydroxide of 0.25 N with phenolphthalein as the indicator until the first permanent pink colour appears [8].

To determine the peroxide value, the FVCO sample was dissolved as a mixture of oil and acetic acid 3:2 (v/v). The mixture was left to react in the darkness with the saturated potassium iodide solution. Finally, iodine was titrated with sodium thiosulfate and the peroxide value was calculated [9].

3. Results and Discussion

3.1. The Temperature of FVCO
After microwave heating, the fermented virgin coconut oil (FVCO) temperature had increased dramatically (Figure 1). The initial FVCO temperature was approximately 28-29°C, and the final FVCO temperature was 71-87°C. However, the oil temperature after microwave heating for 50 and 60s has high standard deviation about 8 to 9°C. The previous study showed that after 36minutes microwave heating, the temperature of canola, corn and soybean oils had increased similarly from 28 to 260°C[4]. As can be seen from figure 2, the FVCO temperature had followed the same trend as the canola, corn and soybean oils temperature, i.e. after 1 minute microwave heating the oil temperature had reached about 60 to 90°C. Another study had reported that the temperature of olive oil after 12 and 15 minutes microwave heating at power 1,100W was 190 and 203°C, respectively [13].

According to analysis of variance (ANOVA), the microwave heating time had significantly influenced the FVCO temperatures (P>0.05). However, the temperature after microwave heating for 50 and 60s was not significantly difference. Generally, the temperature development of microwave
heating following the exponential curve [4, 6]. It was explained that during the microwave heating the absorptivity values would also rise [4].

![Figure 1](image1.png)

**Figure 1.** The fermented virgin coconut oil (FVCO) temperature after microwave heating at volume of 40 ml

Although it is already known that oil samples would heat faster in a microwave oven than do water samples of the same mass, the heating rate of 50g water sample is several times greater than that of an oil sample. This phenomenon can be explained by 3% of the microwave power is reflected by an oil-air interface, but about 64% of the microwave power is reflected at a water-air interface to cause strong resonant heating [14]. It can be said that the sample size strongly influences the behaviour of microwave heating.

![Figure 2](image2.png)

**Figure 2.** The oil temperature development during the microwave heating [4]

### 3.2. The Moisture Content of FVCO

The initial moisture of FVCO oil was 0.36%. After microwave heating for 40 and 60s, the moisture had risen to 0.74 and 0.91%, respectively. However, after 50s microwave heating the moisture of
FVCO oil was dropped to 0.28%. High standard deviations were also determined after microwave heating 40 and 60s where the moisture of FVCO had increased. According to ANOVA analysis, the microwave heating time did not influence the moisture of FVCO.

![Figure 3. The fermented virgin coconut oil (FVCO) moisture after microwave heating at volume of 40ml](image)

The moisture content of crude palm oil (CPO) had decreased as heating time under microwave oven was extended between 10 to 18 minutes. It was caused by the utilization of water to generate heat during microwave irradiation [8]. However, after 40 and 60s microwave heating, the moisture of FVCO had increased. It could be caused due to short microwave heating applied for this experiment. According to the previous study, a 360W microwave-heating for 10 minutes on palm fruitlet had performed the best oil quality[7]. In addition, to produce red palm oil (RPO), the best time and microwave power combination was 14 minutes and 800 W, respectively [8]. Therefore, considering the results of this study, the extension of heating time could be used to improve the oil quality.

According to some standards, the maximum moisture of VCO is 0.5% (APCC standard)[11], and 0.2% (SNI standard)[15]. Therefore, the microwave heating for 50s was better than the microwave heating for 40 and 60s with the moisture met the APCC standard. The initial moisture of FVCO had also met the APCC standard, but it did not meet the SNI standard. The increased moisture after microwave heating at 40 and 50s could be as the interaction of microwave with the FVCO to release the water.

### 3.3. The Free Fatty Acid Value of FVCO

The initial free fatty acid (FFA) of the FVCO was 6.63%. The percentage of fatty acid is the most important parameter quality used for vegetable oils [11]. The APCC standard for FFA was less than 0.5%, the SNI standard for FFA was less than 0.2%, while the Codex Alimentarius standard for FFA was 0%. According to figure 4, it can be seen that there is a slight decrease of FFA content after microwave heating. Moreover, the FFA content of FVCO was very high and did not meet all standards. This high value of FFA could be influenced by the storage time of oil, where it is reported that the production of the FVCO oil was about 3 years ago.

According to ANOVA analysis, the microwave heating time did not influence the FFA content of FVCO. The FFA content of red palm oil after microwave heating between 10 and 18 minutes was 1.27% [8]. The VCO samples gave an average FFA value of 0.131%, with a range of 0.037 to 0.337%. For RBD CNO samples, the FFAs were lower as expected, with an average of 0.021% and a range of
0.008 to 0.076%, while the copra oil samples gave a relatively higher FFA average of 1.410% with a range of 0.660 to 2.502% [11]. Heating time for 40 min at power 90W has most effective for FFA increasing control, and by using 360W power, the heating time for 20min was sufficient to control FFA content [7]. Therefore, the extended heating time above 60s is proposed to reduce the FFA content of FVCO.

![Figure 4. The fermented virgin coconut oil (FVCO) FFA after microwave heating at volume of 40ml](image)

### 3.4. The Peroxide Value of FVCO

The initial peroxide value of FVCO was 7.09 meq/kg oil. According to the Codex Alimentarius, the peroxide value was less than 15 meq/kg oil, while according to the APCC standard, the peroxide value was less than 3 meq/kg oil. Therefore, the peroxide value of FVCO had met the Codex Alimentarius standard. However, high standard deviation of FVCO peroxide value was also recognized after the microwave heating 40 and 50s. The increase of heating time tends to reduce the standard deviation of the peroxide value of FVCO.

Coconut oil is the most oxidatively stable vegetable oil; therefore, the oxidative rancidity is not a significant cause of degradation [11]. After microwave heating for 40 and 50s, the peroxide value of FVCO had increased, while after 60s microwave heating, the peroxide value of FVCO had declined.

The VCO sample that gave the highest peroxide value of 1.86 meq/kg oil was processed using heat. RBD CNO samples, on the other hand, gave an average peroxide value of 0.98 meq/kg oil and a range of 0.27 to 3.39 meq/kg oil. Copra oil gave the highest average peroxide value of 1.48 meq/kg oil with a range of 0.72 to 2.77 meq/kg oil. Higher peroxide values are consistent with high processing temperatures[11]. According to figure 5, it can be described that the best heating time to maintain the peroxide value of FVCO was above 60s.
The study showed that the initial moisture of FVCO had met the APCC standard, the peroxide value of FVCO had met the Codex Alimentarius standard, but the FFA content of FVCO did not meet both standards. The FVCO quality needs to be improved to meet both standards. The microwave heating from 40 to 60s had influenced FVCO temperatures, but it did not influence the moisture, FFA and peroxide value of FVCO. The quality changes could be seen if the microwave heating time increases, therefore it is suggested to extend the microwave heating of FVO to improve the quality of oil. The combination of power and volume could be used as further approach to study the quality changes of FVCO under microwave heating.

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