



## EFFECT OF EXTRACTION METHOD VARIATIONS ON THE QUALITY OF VIRGIN COCONUT OIL (VCO)

Gusti Randy Pratama<sup>1\*</sup>, Andiyono<sup>2</sup>, Junardi<sup>3</sup>, Hajjah<sup>4</sup>, Narni<sup>5</sup>

<sup>1,2,3,4,5</sup>Department of Food Agroindustry, Politeknik Negeri Sambas

Email: [gustirandy@gmail.com](mailto:gustirandy@gmail.com)

\*correspondence

### Abstract

Virgin Coconut Oil (VCO) is an unrefined oil obtained by the extraction of coconut flesh. The extraction procedure influences the sustainability of VCO commercialization. The challenges posed by the agro-industry in extracting coconut oil using various extraction processes deserve additional investigation. This study aimed to identify the effect of different extraction methods on VCO quality and to select the optimal VCO extraction method. The study utilized a single factor Completely Randomized Design (CRD) with three replications. Natural fermentation, induction fermentation, enzymatic, freezing, and heating were among the extraction methods employed. The observed responses were moisture content, free fatty acid content, and peroxide value. The findings revealed that different extraction procedures did not affect VCO's moisture content. The free fatty acid content changed dramatically. The freezing approach was the most effective treatment for free fatty acid response, with a value of 0.058%. Variations in extraction procedures significantly influenced the peroxide value response. The enzymatic approach produced the best peroxide value response (0.12 mg ek/kg).

Keywords: VCO; extraction; experimental design; coconut

### 1. Introduction

Virgin coconut oil (VCO) is the most valued coconut-based product globally (Pestaño et al., 2022). VCO is an unrefined oil extracted from coconut flesh (Asmoro et al., 2018). VCO has a distinctive characteristic. It is colorless with a fresh coconut aroma and has been widely consumed for various purposes, including bread production, infant nutrition, and cosmetics (Ghani et al., 2018). In the food industry, the presence of VCO is more widely used as cooking oil, substitutes for buttermilk, cheese and ice cream (Asiah et al., 2019).

VCO is an oil that can be extracted mechanically or naturally from mature and fresh coconut kernels, with or without the use of heat, without chemical refining, bleaching, or deodorizing, and without changing the oil's composition (Bautista et al., 2023). Extraction is a critical phase in the commercialization of VCO (Agarwal, 2017). Common extraction strategies utilized in modern industry encompass cold extraction, hot extraction, low-pressure extraction, freezing methods, fermentation, centrifugation, enzymatic extraction, and supercritical carbon dioxide extraction (Ng et al., 2021).

Previous research indicates that the optimal yield is achieved with low-pressure extraction. The VCO extraction approach by fermentation provides VCO of higher quality than other methods (Mansor et al., 2012). However, it is time-consuming compared to alternative procedures, such as heat extraction.

Hot extraction produces a higher yield than cold extraction (Agarwal, 2017). It involves grating and squeezing coconut to produce coconut milk and heating at high temperatures to produce VCO. Although hot extraction can produce VCO quickly, it can eliminate beneficial nutrients (Agarwal, 2017). VCO has been known for its high lauric acid content, which is between 46.36% and 48.42% (Suryani et al., 2020)

The enzymatic method is regarded as an efficient means of producing VCO, as it prevents the degradation of essential components by avoiding excessive heat (Amran et al., 2023). The yield of VCO during natural fermentation was 19% without the addition of crude papain enzyme, and it peaked at 27.7% with the incorporation of 1 g of the enzyme (Jakfar



et al., 2023). This study's results prove that the incorporation of enzymes can enhance the yield of VCO.

The enzymatic method is highly advantageous because enzymes are nontoxic and specific catalytic agents derived from natural materials. Consequently, they are environmentally friendly (Amran et al., 2023). However, compared to other extraction procedures, enzymatic extraction produces the lowest yield (Sundrasegaran & Mah, 2020). Each extraction method has benefits and drawbacks. As a result, the industry must decide which method to utilize to suit market demands (Ng et al., 2021).

It is essential to examine the issues encountered by the industry in coconut oil extraction through various ways to facilitate advancements in VCO extraction technology for more efficient downstream processes (Ng et al., 2021). This study aimed to identify the effect of variations in extraction methods on the quality of VCO, explicitly aiming to discover the optimal extraction method for the quality criteria of moisture content, free fatty acids, and peroxide value.

## 2. Methods

### 2.1 Tools and Materials

The materials used were grated coconut flesh devoid of the outer skin, distilled water, tempeh yeast, papain enzyme, 95% alcohol, phenolphthalein, sodium hydroxide, chloroform (p.a), glacial acetic acid, potassium iodide, sodium thiosulfate, filter paper, and starch indicator. The tools used were a drying oven, analytical balance, digital scale, weighing bottle, spatula, desiccator, Erlenmeyer, funnel, digital burette, hot plate stirrer, measuring flask, measuring cup, measuring pipette, dropper pipette, beaker, freezer, electric stove, pan, basin, iron tongs, stirrer, bottle, sieve/mesh 60, and plastic jar.

### 2.2 Research Design

This research employed a single-factor Completely Randomized Design (CRD), namely a variation of the extraction method, with three replications. The variation of the extraction method is presented in Table 1. The Least Significant Difference (LSD) further test was employed to identify treatments with substantial disparities and to ascertain the optimal treatment. The data were processed using Ms. Excel. The RAL and LSD equations are defined in Eq. 1 dan Eq. 2.

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij} \quad (1)$$

Note:

$Y_{ij}$  = response (moisture content, free fatty acids, and peroxide value) of the  $j$  replication of the  $i$  treatment

$\mu$  = mean of response

$\tau_i$  = the effect of treatment  $i$

$\varepsilon_{ij}$  = random influence of the  $j$  replication that received the  $i$  treatment

$$BNT\alpha = t(\alpha; db\ error, v) \sqrt{\frac{2KError}{r}} \quad (2)$$

**Table 1.** Variations of VCO extraction methods

Treatment Code	Extraction Method
T1	Natural fermentation (control)
T2	Induced fermentation (tempeh yeast)

T3	Heating
T4	Freezing
T5	Enzymatic (papain)

### 2.3 VCO Production

The VCO production utilizing the natural fermentation process was as follows. Grated coconut was combined with water in a 1:1 ratio and subsequently pressed to extract coconut milk. The coconut milk was allowed to rest for 30 minutes to facilitate the separation of the coconut cream from the water. Five hundred grams of separated coconut cream were placed in a container and kept at ambient temperature for 48 hours to produce VCO. The induction and enzymatic fermentation methods were similar to natural fermentation. The difference was that 1 g of tempeh yeast was added during the induction fermentation, whereas 1 g of papain enzyme was added during the enzymatic process.

Extraction by heating was as follows. VCO was extracted by heating coconut milk at 100-120 °C for 60 minutes until the water was completely evaporated (EM et al., 2023). The freezing method was carried out by freezing the coconut cream for 24 hours in the freezer and thawing it at room temperature for 24 hours to produce VCO.

### 2.4 Observed Variables

#### 2.4.1 Moisture Content

The moisture content is a quality criterion of virgin coconut oil (VCO). According to the SNI standard for virgin coconut oil (VCO), the maximum permissible moisture content is 0.2% (Badan Standardisasi Nasional, 2008). The moisture content was determined by weighing 5 mL of VCO and drying it in an oven until a consistent weight was achieved. The formula for calculating moisture content is provided in Equation 3.

$$\text{Moisture content (b/b)} = \frac{\text{initial weight} - \text{dry weight}}{\text{initial weight}} \times 100\% \quad (3)$$

#### 2.4.2 Free Fatty Acid

The concentration of free fatty acids reflects the extent of oil degradation resulting from fatty acid oxidation. The formula employed is defined in Eq. 4.

$$\text{Free fatty acid} = \frac{V \times N \times 200}{m \times 10} \times 100\% \quad (4)$$

Note:

V = volume of NaOH required in titration (ml)

N = normality of NaOH

m = sample weight (g)

200 = molecular weight of lauric acid

#### 2.4.3 Peroxide Number

The peroxide number test determines oil degradation or the degree of oil damage. It was conducted to assess the extent of oil degradation resulting from different extraction processes employed. The equation for determining the peroxide number is provided in Eq. 5.

$$\text{Peroxide number (mg/kg)} = \frac{(V_1 - V_0) \times N}{m} \times 100\% \quad (5)$$

Note:

V<sub>0</sub> = volume of sodium thiosulfate solution for blank titration (ml)

V<sub>1</sub> = volume of sodium thiosulfate solution for sample titration (ml)

N = normality of standard sodium thiosulfate solution used

$m$  = sample weight (g)

### 3. Results and Discussion

#### 3.1 Moisture Content

Moisture content refers to the quantity of water present in VCO (Harimurti et al., 2020). Based on Table 2, the calculated F value is less than the F table. This indicates that the variance in treatments does not influence the quality of the moisture content of VCO. The moisture content of the five treatments evaluated exhibited no significant differences according to the RAL results; hence, additional BNT testing was not pursued.

**Table 2.** Analysis of the variety of moisture content of VCO

Source of Diversity	Degrees of Freedom	Sum of Squares	Middle Square	F-count	F-table	
					5%	1%
Treatment	4	0.00347	0.000866	1.783657	3.48	5.99
Error	10	0.00486	0.000486			
Total	14	0.00832				

#### 3.2 Free Fatty Acid

High free fatty acid values indicate a decrease in oil quality. This results from the acid generated during the oil hydrolysis (Amran et al., 2023). Based on Table 3, the calculated F value is greater than the F table at the 5% and 1% significance levels. This shows that variations in extraction methods have a very significant effect on the tested response. Further BNT testing was required to identify treatments with significant differences and determine the optimal treatment among the five treatments utilized.

**Table 3.** Analysis of free fatty acid diversity

Source of Diversity	Degrees of Freedom	Sum of Squares	Middle Square	F-count	F-table	
					5%	1%
Treatment	4	0.002644	0.000661	62.56696	3.48	5.99
Error	10	0.000106	0.000011			
Total	14	0.002749				

In Table 4, treatment T4 exhibits the lowest average free fatty acid value, denoted by the letter a, at 0.058%. Treatment T4 (freezing extraction) was the best treatment for free fatty acid quality. The BNT calculation shows that each treatment differs significantly. Treatment E, which used an enzymatic extraction approach, produced the highest amount of free fatty acids. All treatments met the quality criteria set by SNI specifications (max 0.2%).

**Table 4.** Further test of BNT at 5% real level on free fatty acid quality

Treatment	Average (%)*
T1	0.079 c
T2	0.083 cd
T3	0.068 b
T4	0.058 a
T5	0.096 e

\* The difference in the final letter notation signifies a substantial distinction in each treatment as per the BNT test.

#### 3.3 Peroxide Number

The peroxide value indicates VCO quality, which might lead to oil rancidity (Amran et al., 2023). Based on Table 5, the calculated F value is greater than the F table of 5%, but less than the F table of 1%. This figure indicates that the treatment variations have significant

differences. Consequently, more testing was required to ascertain the optimal treatment regarding the peroxide number quality factors.

**Table 5.** Analysis of peroxide number variance

Source of Diversity	Degrees of Freedom	Sum of Squares	Middle Square	F-count	F-table	
					5%	1%
Treatment	4	0.01642	0.00410	5.50053	3.48	5.99
Error	10	0.00746	0.00075			
Total	14	0.02388				

According to BNT results at a significance level of 5% (Table 6), treatment T5 (enzymatic) exhibited the lowest peroxide number, recorded at 0.12 mg ek/kg. The enzymatic method was the best treatment in terms of peroxide response. Treatments T2, T3, and T4 exhibited identical effects as determined by the BNT calculation. The test results indicated that all treatments complied with the SNI standard (maximum 2.0 mg ek/kg).

**Table 6.** Further test of BNT 5% peroxide number

Treatment	Average (mg ek/kg)*
T1	0.13 ab
T2	0.17 abc
T3	0.21 c
T4	0.17 abc
T5	0.12 a

\* The difference in the final letter notation signifies a substantial distinction in each treatment as per the BNT test.

### 3.4 Moisture Content

Varying extraction methods did not provide a significant difference in the results of VCO water content. This finding is different from (Mansor et al., 2012) which used freezing, fermentation and enzyme extraction methods but had very significantly different results from each treatment used. Different extraction procedures could be the cause of differences in the results of this study. In the fermentation method, this research only added 1 g of yeast, which is different from previous research which added 2 g of yeast. Likewise, in the freezing and enzymatic techniques, previous researchers used a centrifuge to stir the coconut milk until it was homogeneous. This research only uses manual stirring so the stirring speed is not consistent. This can affect the separation of water and VCO.

### 3.5 Free fatty acids

The freezing fermentation method (T4) was the best treatment for the free fatty acid test. The free fatty acid content obtained was 0.058%, the smallest compared to other extraction methods. In line with research (Wickramasinghe Mudiyansele & Wickramasinghe, 2023), the yield of VCO free fatty acids was 0.05% in the CRISL 2013 variety. Research (Ghani et al., 2018) showed a greater value of 0.17% in the free fatty acid test by freezing extraction and 0.53% by natural fermentation technique. Natural fermentation was carried out by standing for 72 hours, while the natural fermentation in this study was 48 hours. This causes the free fatty acid value obtained in the natural fermentation method in this research to be 0.079% (Table 4) which is much smaller than in previous research. The duration of the VCO oil extraction process affects quality (Rahardjo & Firdaus, 2019). The faster fermentation had better the free fatty acid content, but this can also reduce the yield of VCO produced.

### 3.6 Peroxide number

Based on the results of further BNT tests, the induction fermentation, heating and freezing methods did not have any significant differences (Table 6). Enzymatic methods and

natural fermentation have a real impact. The peroxide value obtained by the enzymatic method is the smallest compared to other methods, namely 0.12 mg ek/kg. The test results are smaller than research (Amran et al., 2023) which had a peroxide value range of 1.3 – 2 mg ek/kg. This study had an incubation time of 48 hours, whereas previous research had an incubation time of 6-24 hours. Previous research findings reveal that long incubation time can increase the peroxide value. Despite the discrepancy in results from previous researchers, the findings of this study show that an incubation time of 48 hours still obtained a smaller peroxide value than a shorter incubation time.

#### 4. Conclusion

The variation in extraction methods had a very significant effect on the free fatty acid content and a significant effect on the peroxide number. The variation in extraction methods did not influence the quality of moisture content in VCO. In terms of free fatty acid quality, the freezing extraction method outperformed the other extraction methods with a value of 0.058%. The enzymatic extraction method was the most effective treatment regarding peroxide number quality, with a 0.12 mg/kg value.

Additional investigation into current VCO extraction techniques is required. Subsequent study should incorporate VCO quality testing characteristics, including iodine number, fatty acid composition, and microbiological factors, to yield more comprehensive test results in accordance with SNI and other VCO standards.

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