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Quality Analysis of Fermented *Virgin Coconut Oil* (VCO) Purified by Silica Slag Nickel Filtration

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Abstract
This study has been conducted on Quality Analysis of Fermented Virgin Coconut Oil (VCO) with Purification using Nickel Silica Slag by Filtration. This study aims to describe the physical, organoleptic and chemical qualities of fermented VCO purified with nickel silica slag. The results showed that the VCO result value obtained was 9.33% (v/v), with the organoleptic test of Fermentation VCO before and after filtration, namely colors 3.93 and 4; smells 3.20 and 3.27, and tastes 2.80 and 2.80. Determination of the physical quality of Fermented VCO with clarity values before and after respectively, Transmission 90.0% and 92.0%. Determination of the chemical quality of Fermented VCO before and after Filtration, namely the moisture content value of 0.31% and 0.08%, respectively; the value of free fatty acid content is 0.17% and 0.15%; The peroxide values were 0.53 mg eq/kg and 0.52 mg eq/kg, and the saponification values were 189.16 mg KOH/g and 249.30 mg KOH/g. The results of the chemical quality analysis in this study are in accordance with SNI No. 7381 of 2008 and SNI No. 7431 of 2015. Therefore, it can be concluded that VCO absorbed using nickel silica slag can improve its physical and chemical qualities.

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INTRODUCTION

Indonesia is one of the largest coconut tree producing countries in the world, with coconut production reaching 18.3 million tons in a year (Idn Times, 2020). This coconut has become one of the drivers of Indonesia's economy. The coconut tree is one of the trees that is used and used by all parts of the coconut. Coconut fruits have many benefits both in the form of old coconuts and in the form of young coconuts. Coconut has many benefits including virgin oil (VCO). A high-quality VCO can be recognized by its physical characteristics that are clear in color, have no rancid aroma, and have a distinctive taste like coconut. This characteristic is an indicator that the product is pure and not contaminated by other mixed ingredients.

The creation of VCO can be done through various techniques, which are generally categorized into two, namely the method with heating and the method without heating (the cold method). Compared to the heating method, the cold method has a number of advantages, especially in terms of product quality, such as a higher antioxidant content. Therefore, this method is often chosen to produce superior quality VCO (Sutanto et al., 2021). The process of making VCO by fermentation method has significant advantages. Compared to other methods, this technique is known to be easier and cheaper to do. Another advantage is the quality of the final product, where the oil produced has a very clear and clear appearance (Nury et al., 2023). According to Tamzil (2017), the manufacture of VCO can be done by several methods, namely fishing, fermentation, enzymatic, and centrifugation methods (Idris and Puspita, 2022). In terms of quantity, the VCO obtained by the fishing method was obtained

6.25% (Bambang et al., 2017), the centrifugation method was 9% (Wong and Hartina, 2014), the fermentation method was 36.8% and the enzymatic method was obtained as much as 46.8% (Karyani, 2024).

The quality of VCO greatly determines consumer acceptance and its selling value in the market. The quality of the VCO of each method has different results. In terms of quality, the VCO produced by the fishing method has a moisture content of 0.1566%, a free fatty acid content of 0.1744%, a peroxide number of 0.3545 mg ek/Kg and a saponization number of 281.12 mg KOH/Kg (Oktaviansyah, 2023), an enzymatic method obtained a moisture content of 0.34%, a free fatty acid content of 0.6% (Rindawati et al., 2020), a peroxide number content of 2.704 meq/Kg (Fitriani et al, 2021) and the rate of the number of soaps was 69.94 mg KOH/g. The centrifugation method was 0.12% water content, free fatty acid content 0.16% and peroxide number content 1.22 mg ek/Kg (Yadi et al., 2018), and the fermentation method obtained a moisture content of 0.1333%, a free fatty acid content of 0.3671%, and a peroxide number content of 0.2148 meq/Kg (Pontoh et al., 2008).

It appears that the fermentation method is the easiest method to do by the community. However, the problem is that the quality of the VCO produced is not optimal and has less stable quality, is characterized by being easily rancid, and often freezes at room temperature, especially in the morning. According to Nia et al, (2024) oil becomes rancid due to oxidation reactions, where unsaturated fats in acidic conditions break down to form peroxide and free radicals in the initial stage. Oil freezing indicates a problem in the production process, thus triggering a hydrolysis reaction. The high moisture content causes the economic value of VCO to be low.

Attempts to purify the VCO can be done by filtering using adsorbents. According to Fatimah et al. (2010), several adsorbents that can be used in VCO purification are zeolite, activated charcoal, and rice husk ash, where rice husk ash contains silica that can absorb water. Silica is a chemical compound with the molecular formula SiO2 (silicon dioxide) which is a chemical compound consisting of silicon and oxygen that can be obtained from mineral silica, vegetable and crystal synthesis (Putri et al, 2021). Some examples of silica sources include rice husks, bagas sugarcane (bagasse), bamboo leaves, oil palm, salak fruit (Nugroho and Yudha, 2024) and nickel slag (Amalia, 2024). Silica is widely used as an adsorbent in the adsorption process due to the presence of an active group of silanol (≡Si-OH) and siloxane (≡Si-O-Si≡) (Putri et al., 2021).

METHOD

Production of VCO

The coconut fruits used to make VCO are old and ungrown coconuts, thick and odorless. Next, as many as 10 coconuts are separated from the shell, washed, drained, and grated. Furthermore, the grated coconut was then weighed as much as 3,765 kg with water added with a ratio of water and coconut which is 1:1. Squeeze 2 times, until all the coconut milk in the grated coconut is extracted. The mixture of coconut milk and water obtained was left to sit for two hours to separate the skim and cream, the result obtained was in the form of water and thick coconut milk (cream) (Haerudin et al., 2023). Then the skim is discarded and the cream is left to sit again for 2 hours, then the skim is separated (Pontoh et al., 2008). Then the cream obtained is fermented for 11 hours until 3 layers are formed, namely blondo, VCO and water (Rosita et al., 2022). The adsorbent is arranged with an adsorbent height of 2-3 cm silica slag and then put into a filtration column with a length of 30 cm and a diameter of 3 cm. Next, the VCO is inserted into the column that has been given an adsorbent, with a flow rate of 8 drops per minute.

Determination of VCO Physics Parameters (Clarity)

Samples were taken as much as 1 ml dissolved in aquaedes using a 100 ml measuring flask. Furthermore, measurements were made with a UV Vis spectrophotometer at a wavelength of 650 nm. The percentage of transmitters with a percentage of 90%-100% proves that the mixture has a transparent and clear appearance (Asrawaty et al., 2020).

Determination of VCO Chemical Parameters

Determination of Moisture Content

The weighing bottle was heated in an oven at 105°C for 1 hour. It was then cooled in a desiccator for ½ hour, and its weight was recorded. Next, 5 grams of virgin coconut oil (VCO) was weighed into the weighing bottle whose weight had already been determined. Heat in an oven at 105°C for 1 hour, then cool in a desiccator for half an hour. Weigh the weighing bottle containing the sample.

Repeat the heating and weighing process until a constant weight is obtained The moisture content is expressed as weight percent, calculated to two decimal places using the formula (Lestari and Cahyadi, 2023).

$$\text{Moisture Content} = \frac{A - B}{A} \times 100\%$$

Where:
A = weight of the sample (oil) before heating
B = weight of the sample (oil) after heating

Determination of Free Fatty Acid

The oil sample is stirred in its liquid state, then 5 grams are weighed into an Erlenmeyer flask. Next, add 50 mL of 96% neutral alcohol and 5 drops of phenolphthalein (PP) indicator. Then titrate with a standardized 0.1 N NaOH solution until the solution turns pink and the color persists for 30 seconds. Free fatty acids are expressed as % FFA (*free fatty acid*) or as an acid value. The acid value is the mg of KOH required to neutralize 1 gram of oil. Free fatty acids (calculated as lauric acid) are expressed as a percentage of fatty acids, calculated to two decimal places using the formula (Lestari and Cahyadi, 2023).

$$\text{FFA (Free Fafty Acid)} = \frac{V \times N \times 200}{m \times 10}$$

Notes:
V = volume of NaOH for titration (mL)
N = Normality of NaOH
m = Sample weight (grams)
200= molecular weight of lauric acid

Determination of Peroxide Value

Sample Weigh 0.3–5 grams of the sample, add 10 mL of chloroform, and dissolve the sample by vigorously shaking the Erlenmeyer flask. Add 15 mL of glacial acetic acid and 1 mL of saturated potassium iodide solution. Immediately cap the Erlenmeyer flask and shake for approximately 5 minutes in the dark at a temperature of 15°C–25°C. Titrate with a 0.02 N sodium thiosulfate standard solution using starch solution as an indicator. Perform a blank determination. The peroxide value can be expressed in milligrams of active oxygen equivalent per kilogram. Calculate to two decimal places using the formula (Lestari and Cahyadi, 2023)

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

Notes:
V_0 = Volume of 0.02 N $Na_2S_2O_3$ required for the blank titration (mL)
V_1 = Volume of 0.02 N $Na_2S_2O_3$ required for the sample titration (mL) N
N = Normality of $Na_2S_2O_3$
m = Sample weight (grams)

Determination of the Saponification Number

The saponification value was determined using the acid-base titration method. 1.5 g of coconut oil sample was weighed into a 250 mL Erlenmeyer flask, and 50 mL of 0.5 N alcoholic KOH solution was added, followed by optimization of the saponification reaction time and heating temperature. The sample was heated for 35 minutes at a heating temperature of 60°C. One milliliter of phenolphthalein indicator solution was added to the flask and titrated with 0.5 N HCl until the pink color completely disappeared. The volume of 0.5 N hydrochloric acid consumed in the titration was recorded (Haeruddin et al., 2023).

$$\text{Saponification Number} = \frac{56{,}1\,(B - C)N}{M}\ \text{mg}\ \frac{KOH}{g}\ \text{oil}$$

Notes:
B = Volume of 0.5 N HCl consumed in the blank titration, expressed in milliliters (mL);
C = Volume of 0.5 N HCl consumed in the sample titration, expressed in milliliters (mL);
N = Exact concentration of the 0.5 N HCl solution, expressed in normality (N);
m = Weight of the sample (g).

RESULTS AND DISCUSSION

Production of VCO

The results of the study indicate that the fermentation of coconut milk results in a gradual phase separation that becomes increasingly distinct as the fermentation time increases. During the initial settling stage, the coconut milk separates into cream and skim fractions, with the cream fraction having a smaller volume than the skim fraction, indicating that the coconut milk system is still dominated by the aqueous phase. Continued settling leads to further separation, where the cream volume decreases and the skim fraction reforms, indicating that water and non-fat components remain trapped within the initial cream. The absence of separation during short fermentation suggests that fermentation time significantly influences the stability of the coconut milk emulsion. The most optimal separation occurred during 11 hours of fermentation, resulting in three distinct layers: blondo, VCO, and water. According to Isniani et al. (2025), the fermentation process requires a certain amount of time for microorganisms to produce sufficient acids and enzymes to break down the emulsion structure. A fermentation time that is too short causes the emulsion to remain stable, so oil separation has not yet occurred.

The VCO yield obtained in this study was 9.33%, calculated from the ratio of VCO volume (700 mL) to the volume of coconut cream (7500 mL). This yield value remains within the range of VCO yields from the fermentation method reported in the study by Prasanna et al. (2024), which is approximately 9.23–33.25%, and can therefore be categorized as good. This yield indicates that fermentation for 11 hours was sufficiently optimal to produce virgin coconut oil, although some cream fractions remained in the form of blondo and the aqueous phase. Thus, the results of this study confirm that fermentation is an effective method for VCO production

Organoleptic Testing

Organoleptic testing is a method of measuring, evaluating, or testing the quality of a product using the sensitivity of the human senses, namely the eyes, nose, mouth, and fingertips. Organoleptic testing is also referred to as subjective measurement because it is based on human subjective responses as the measuring tool (Handayani and Rosidah, 2017). The results of the color analysis of VCO before and after filtration using nickel slag silica, as evaluated by the panelists, can be seen in Figure 1.

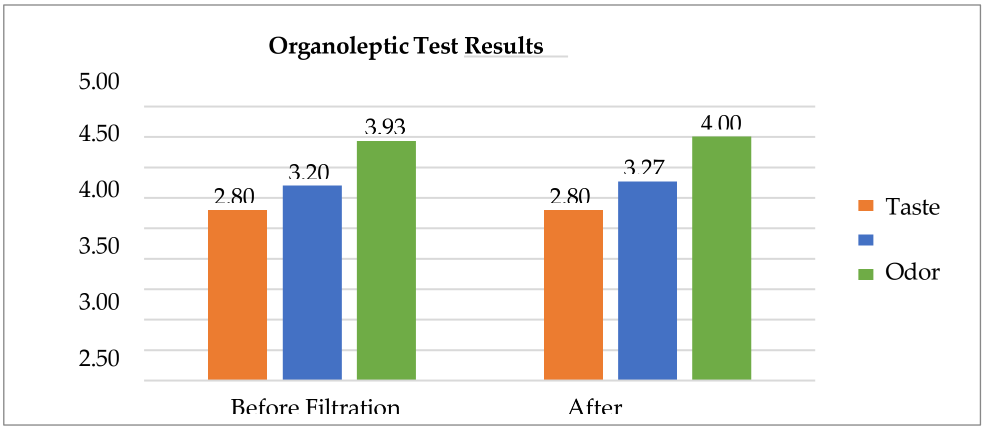

Figure 1. Average Results of the VCO Organoleptic Test

Based on the data in Figure 1, it is evident that the organoleptic test results for VCO color, both before and after filtration, show good values. Before filtration, the score was 3.93, indicating that the score was nearly at the very good level of 4. After filtration using nickel slag silica, the VCO color became clear. This indicates that the filtration process does not cause significant changes in the oil's color and does not trigger reactions that could degrade the visual quality of VCO. According to Pratysentani et al. (2024), silica-based filtration media are known to be inert toward oil and function to filter or adsorb residual impurities without affecting the oil's natural color. These results are in accordance with SNI 7381-2008, which states that high-quality VCO generally has a color ranging from clear to pale yellow.

The results of the organoleptic odor test for VCO, both before and after filtration, both revealed a coconut odor. The scores for VCO before and after filtration differed by only 0.05. These results indicate that fermented VCO, whether unfiltered or filtered using nickel slag silica retains a coconut scent and is not rancid. The SNI 7381:2008 standard stipulates that one of the quality requirements for VCO is a characteristic coconut scent. Based on this requirement, the VCO produced in this study meets the quality standards for VCO as per SNI, specifically having a fresh coconut aroma and no rancid odor. Asrawaty et al. (2020) state that high-quality VCO is characterized by oil that is colorless, free of sediment, has a distinct coconut aroma, no rancid odor, and no sour taste. A change in VCO aroma to a rancid odor may indicate that the oil has undergone degradation, particularly due to oxidation or deterioration in oil quality (Shipahelut, 2025).

The average scores from the organoleptic taste test for VCO before and after filtration were both 2.80. These results indicate that the filtration process did not significantly affect the taste characteristics of VCO. In other words, the taste of VCO remained stable even after undergoing filtration. A score of 2.80 indicates that the panelists rated the VCO's taste as falling within the neutral to distinct coconut flavor category, without any off-flavors such as sourness, bitterness, or rancidity. This indicates that during processing and filtration, VCO did not undergo chemical degradation that could affect its taste. SNI 7381:2008 standard stipulates that one of the quality requirements for VCO is that it possesses the characteristic flavor of coconut oil. The results of the organoleptic taste test in Figure 1 show that the produced VCO maintains a consistent flavor before and after filtration and still meets the characteristics of high-quality VCO.

Determination of the Physical Quality of Fermented VCO

Physical quality analysis is the process of testing and evaluating the quality of a material or product based on its physical properties that is, characteristics that can be observed or measured without altering the material's chemical composition. This analysis aims to determine the condition, stability, and conformity of the product to applicable quality standards, as well as its visual and sensory acceptance. Clarity is one of the key aspects in determining the physical quality of VCO, as clarity is directly related to the oil's visual appearance and the presence of suspended substances such as solid particles or water emulsions.

Clarity can be measured quantitatively using the transmittance percentage, which is the percentage of light that can pass through the oil sample at a specific wavelength. A high transmittance value indicates that the oil is relatively clear and absorbs or scatters little light, resulting in high optical clarity. The results of the clarity analysis of VCO before filtration and after filtration using nickel slag silica are shown in Table 1. Based on the data in Table 1. It is know that VCO before filtration has a transmittance value of 90.2% and after filtration has a transmittance value of 92.0%.

Table 1. Physical Properties (Clarity) of Fermented VCO

Sample	% Transmittance
VCO Before Filtration	90,2
VCO After Filtration	92,0

These results indicate that the filtration process successfully reduces suspended particles, making the oil clearer and visually more transparent. Such high oil clarity is closely related to the physical quality of VCO, as solid particles or other compounds remaining in the oil will cause a decrease in transmittance and a decline in the product's visual quality. The transmittance percentage (%T) reflects the level of clarity or transparency of an oil sample based on the liquid's ability to transmit light. The higher the transmittance percentage, the clearer the oil, as there are fewer suspended particles or impurities causing light scattering. According to Asrawaty et al. (2020), a transmittance percentage of 90%–100% indicates that the mixture has a transparent and clear appearance. Thus, the transmittance percentage obtained for the fermented VCO indicates a transparent and clear appearance.

Determination of VCO Chemical Quality

Chemical analysis is used to support the implementation of Indonesian National Standards (SNI) 2008 and 2015 regarding VCO Quality Analysis and can benefit the public in assessing the quality of the obtained product. The chemical parameters to be tested include moisture content, free fatty acid content, peroxide value, and saponification value. According to BSN (2008) regarding Coconut Oil (VCO), the maximum limits are: moisture content 0.2%, free fatty acid content 0.2%, and peroxide value 2.0 mg ek/kg; and in SNI (2015) regarding the quality and testing methods for pure vegetable oils, the maximum limit for the saponification value is 180–265 mg KOH/g. Results of the chemical quality analysis of fermented VCO purified using nickel slag silica via filtration.

Moisture Content

Moisture content refers to the amount of water present in a material. According to Pine and Kahitmah (2024), the purpose of testing the moisture content in VCO is to measure the amount of water in the oil. This is important to know because high moisture content can trigger oxidation reactions, which ultimately cause the oil to become rancid and spoil. The results of the moisture content determination of fermented VCO purified using nickel slag silica via filtration are shown in Table 2

Table 2. Moisture Content of Fermented VCO

Sample	Water Content (%)
VCO Before Filtration	0,31
VCO After Filtration	0,08
SNI (2008)	0,2

Based on Table 2 the moisture content before filtration was 0.31% and after filtration was 0.08%. Based on the test results, the moisture content of the VCO oil after filtration met the quality standards set by SNI 7381-2008, namely not exceeding the maximum limit of 0.2%. In the study by Sari et al. (2024), the moisture content obtained via the natural fermentation method was 4.01%. However, according to the study by Pratysentani et al. (2024), VCO purification using activated carbon resulted in a moisture content of 0.04%. This highly significant difference in moisture content is influenced by the purification stage, where VCO purified using an adsorbent has a lower moisture content than VCO without purification using an adsorbent. This is consistent with the moisture content before filtration, which exceeded the quality standards set by SNI. This indicates that VCO oil adsorbed using nickel slag silica exhibits a reduction in moisture content. This is because silica contains active silanol and siloxane groups (Putri et al., 2021).

Free Fatty Acid (FFA)

Free fatty acids are fatty acids that exist in a free form and are not bound within the triglyceride structure. These acids are formed as a result of hydrolysis and oxidation reactions that typically occur in neutral fats. The free fatty acid content indicates the amount of fatty acids released from ester bonds (Vinsensius et al., 2020). Free fatty acid content is often used as a parameter to assess the freshness of an oil. Additionally, free fatty acid levels can be used to determine an oil's shelf life, purity, the intensity of hydrolysis reactions, and as an indicator of potential errors during the manufacturing process. The results of the determination free fatty acid content of fermented VCO purified using nickel slag silica can be seen in **Table 3**

Table 3. Free Fatty Acid Content of Fermented VCO

Sample	Free Fatty Acid (%)
VCO Before Filtration	0,17
VCO After Filtration	0,15
SNI (2008)	0,2

Based on the research results shown in **Table 3**, it is known that the free fatty acid (FFA) content of VCO before filtration was 0.17% and decreased to 0.15% after the filtration process using nickel slag silica. This aligns with the study by Fatima and Sangi (2020), which found a free fatty acid content of 0.21% before filtration and 0.13% after filtration. This is likely due to silica's ability to adsorb water molecules, as reduced water content leads to a decrease in the hydrolysis of triglycerides into free fatty acids. According to Nahak et al. (2023), the amount of FFA in VCO increases in proportion to the moisture content. High moisture content in VCO can facilitate the hydrolysis of triglycerides into free fatty acids and glycerol by the lipase enzymes present in coconuts.

The use of nickel slag silica as a filtration medium can reduce the free fatty acid (FFA) content because this material contains silica (SiO_2), which is polar and has a porous structure. This structure facilitates the adsorption of polar compounds in the oil, including free fatty acids and water. During the filtration process, some of the free fatty acids are adsorbed onto the surface of the nickel slag silica, thereby separating them from the oil phase, which results in a decrease in the FFA value after filtration (Pratysentani et al., 2024).

This decrease in free fatty acid content indicates that the filtration process plays a role in improving VCO quality. According to Hastuti and Rizka (2021), free fatty acids result from the hydrolysis of triglycerides, influenced by the presence of water and oil processing conditions. The higher the water content in the oil, the greater the likelihood of hydrolysis, which leads to an increase in FFA; thus, the decrease in FFA after filtration indicates a reduction in the components triggering this reaction. The amount of free fatty acids in the oil is indicated by the acid value. A high acid value indicates that the free fatty acids present in the vegetable oil are also high, thereby lowering the oil's quality. Based on the test results, the free fatty acid content of VCO oil after filtration meets the quality standards set by SNI 7381-2008, which stipulate that it must not exceed the maximum limit of 0.2%.

Peroxide Value

The peroxide value is a key parameter used to assess the degree of deterioration in oil. Peroxide compounds form when unsaturated fatty acids react with oxygen at their double bonds. Oil is considered to be of good quality if its peroxide value is low, whereas an increase in the peroxide value indicates a decline in VCO quality (Sayakti et al., 2025). The results of the peroxide value determination for fermented VCO purified using nickel slag silica are shown in Table 4

Table 4. Peroxide Value of Fermented VCO

Sample	Peroxide Value (mg ek/Kg)
VCO Before Filtration	0,53
VCO After Filtration	0,52
SNI (2008)	2,0

Based on Table 4, it is known that the peroxide value of VCO before filtration was 0.53 mg ek/kg and decreased to 0.52 mg ek/kg after the filtration process. This is consistent with the study by Fatima and Sangi (2020), in which the peroxide value of fermented VCO before filtration was 0.99 mg EO/kg and 0.27 mg EO/kg after filtration. This decrease in the peroxide value indicates that the filtration process affects the oil's oxidative properties, particularly by reducing the initial products of lipid oxidation reflected in the peroxide value. According to Sinaga et al. (2024), the lower the peroxide value, the lower the level of oxidation occurring, meaning the oil is more stable against quality changes such as the accumulation of free radicals and the development of rancid odors.

Based on the test results, the peroxide value of the VCO oil after filtration met the quality standards set by SNI 7381-2008, namely not exceeding the maximum limit of 2 mg Eq/kg. The peroxide values obtained, both before and after filtration, indicate that the VCO oil in this study falls within a relatively low range compared to several other studies on VCO quality. In the study by Ajogun et al. (2020), a peroxide value of 1.17 mg Eq/kg was obtained using the extraction method. This indicates that the natural fermentation process, combined with filtration, effectively protects the oil from significant oxidative damage while maintaining the oil's chemical stability for both consumption and short-term storage.

Saponification Value

The saponification number is one of the key parameters in the chemical analysis of oils and fats, used to measure the amount of alkali, typically KOH, is required to saponify one gram of oil and fat. Saponification is a chemical reaction in which triglycerides react with a strong base to produce soap and glycerol. The results of the saponification value determination for fermented VCO purified using nickel slag silica are shown in Table 5.

Table 5. Saponification Value of Fermented VCO

Sample	Saponification Value (mg KOH/g)
VCO Before Filtration	189,16
VCO After Filtration	249,30
SNI (2015)	180-265

Table 5 shows that the saponification value of VCO before filtration was 189.162 mg KOH/g and increased to 249.301 mg KOH/g after the filtration process. This increase in the saponification value is consistent with Arifianti's (2024) study on the purification of VCO through filtration neutralization using an adsorbent, where the saponification value before filtration was 280 mg KOH/g, while the saponification value after filtration was 290 mg KOH/g. In the study by Khairani and Nizar (2024), the saponification value was 178.117 mg KOH/g. The higher the saponification value, the greater the ester content in the oil, indicating higher purity. VCO with a high saponification value indicates the presence of pure fat and good quality (Khairani and Nizar, 2024). The higher the saponification number, the lower the molecular weight. A molecular weight that is too high results in a higher fat content, and if the fat content is too high, the oil will solidify easily (Wulandari and Wibowo, 2022). Based on the test results, the saponification values of the VCO before and after filtration met the quality standards set by SNI 7182-2015, which stipulate that the values must not exceed 180–265 mg KOH/g.

CONCLUSION

Based on the results of the study, it can be concluded that the average color organoleptic test before and after adsorption was 3.93 and 4; odor is 3.20 and 3.27; and flavor are 2.8 and 2.8. The results of the VCO physical test obtained before and after adsorption had a transmitter value of 90.2%, and 92.0%. The results of the VCO chemical test contained moisture content before and after adsorption, namely 0.31% and 0.08%; free fatty acids are 0.17% and 0.15%; peroxide number 0.53 mg eq/Kg and 0.52 mg eq/Kg; and the number of saponations was 189.16 mg KOH/g and 249.30 mg KOH/g.

RECOMMENDATION

This research requires further research where silica is made using nickel slag silica, so it is necessary to test the metal content in the VCO oil obtained to ensure the quality obtained both in accordance with SNI standards and for health.

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