ENHANCING THE QUALITY OF COCONUT COOKING OIL THROUGH VARIATION IN YEAST CONCENTRATION AND COOKING TIME

PENINGKATAN KUALITAS MINYAK GORENG KELAPA MELALUI VARIASI KONSENTRASI RAGI DAN LAMA PEMANASAN

Rini Triani[1], Monica Devinor[1], Nasywa Izzata[1], Hervelly[1], Nabila Marthia[1]

[1] Program Studi Teknologi Pangan, FT, Universitas Pasundan, Jl. Dr. Setiabudhi No. 193, Bandung, 40153, Indonesia

Email : rini.triani@unpas.ac.id

Abstract

Coconut oil is derived from coconut fruit. This study explores an alternative processing method involving yeast addition to shorten heating time. The yeast used is baker's yeast (Saccharomyces cerevisiae), which expedites emulsion breakdown in coconut milk. A factorial randomised block design was used with varying yeast concentrations (1%, 2%, 4%, 6%) and heating durations (30 and 45 minutes). Parameters tested included yield, moisture content, acid value, peroxide value, impurity level, turbidity, colorimetric value, and organoleptic properties of colour and aroma. A control group with 0% yeast was also evaluated. Analysis of variance indicated that yeast concentration significantly affects oil quality, whereas cooking time and their interaction do not. The best treatment, using 1% yeast concentration and a 30-minute cooking duration, produced the highest quality oil (de Garmo method), yielding 31.20% with superior characteristics (moisture content <1%, free fatty acid content at 0.33%, and a Brightness L* value of 44.68) compared to traditional commercial coconut oil. This method meets several elements of the Indonesian National Standard (SNI) and offers a more efficient production method yielding high-quality coconut cooking oil. Overall, yeast fermentation enhances coconut oil quality, surpassing the control group, and provides a more efficient production method for high-quality coconut oil.

***Keywords**: Yeast, Coconut Cooking Oil, Cooking Time, Oil Quality, Saccharomyces cerevisiae*

Abstrak

Minyak kelapa diperoleh dari buah kelapa. Penelitian ini mengeksplorasi metode pengolahan alternatif dengan penambahan ragi untuk memperpendek waktu pemanasan. Ragi yang digunakan adalah ragi roti (Saccharomyces cerevisiae), yang mempercepat pemisahan emulsi pada santan. Penelitian dilakukan menggunakan rancangan acak kelompok faktorial dengan variasi konsentrasi ragi (1%, 2%, 4%, 6%) dan lama pemanasan (30 dan 45 menit). Parameter yang diuji mencakup rendemen, kadar air, angka asam, angka peroksida, tingkat kotoran, kekeruhan, nilai kolorimetri, serta sifat organoleptik warna dan aroma. Kelompok kontrol tanpa penambahan ragi (0%) juga dievaluasi. Analisis ragam menunjukkan bahwa konsentrasi ragi berpengaruh signifikan terhadap kualitas minyak, sedangkan lama pemanasan dan interaksi keduanya tidak berpengaruh signifikan. Perlakuan terbaik diperoleh dengan konsentrasi ragi 1% dan lama pemanasan 30 menit yang menghasilkan minyak dengan kualitas tertinggi (berdasarkan metode de Garmo), menghasilkan rendemen sebesar 31,20% dengan karakteristik unggul (kadar air <1%, kadar asam lemak bebas 0,33%, dan nilai kecerahan L* sebesar 44,68) dibandingkan minyak kelapa komersial konvensional. Metode ini memenuhi beberapa kriteria Standar Nasional Indonesia (SNI) dan menawarkan proses produksi yang lebih efisien untuk menghasilkan minyak kelapa berkualitas tinggi. Secara keseluruhan, fermentasi menggunakan ragi meningkatkan kualitas minyak kelapa dibandingkan kelompok kontrol, serta menyediakan metode produksi yang lebih efisien untuk menghasilkan minyak kelapa berkualitas tinggi.

***Kata kunci:** Ragi, Minyak Kelapa, Lama Pemanasan, Kualitas Minyak, Saccharomyces cerevisiae*

1. Introduction

Coconut oil is typically produced using either dry or wet processing methods. In the dry process, coconuts are first dried into copra and then ground into coarse powder. This powder is then heated and pressed to extract the oil. In the wet process, coconut meat is made into coconut milk, which is then heated to evaporate the water content and extract the oil (Firdana & Dewi, 2021).

Coconut oil processing using the wet method is more commonly practiced by the general public due to its simple procedures and equipment. However, the wet method has drawbacks that affect the quality of the coconut oil produced, including a short shelf life and high fuel costs due to prolonged heating. Therefore, modifications to the traditional method are needed to shorten the cooking time and improve the quality of the coconut oil produced. Alternative methods for processing coconut into oil include acidification and fermentation. These alternative methods can reduce cooking time and save on fuel costs. The fermentation method involves adding yeast to accelerate the breakdown of the coconut milk emulsion (Apriyantono, 2014). Adding yeast to coconut milk produces enzymes that break down carbohydrates into acids, which coagulate the proteins in the emulsion. The fermentation method also produces proteolytic enzymes that catalyze protein and carbohydrate molecules in globules, allowing oil molecules to separate from the coconut milk emulsion (Rado, 2015).

Previous research revealed that the fermentation method produces clearer oil with a relatively short heating time (Sukmadi and Nugroho, 2000). Adding 2% yeast resulted in an oil yield of 38.92% and an acid number of 0.09 mg KOH/g oil (Jasman et al., 2019). Using 2% yeast with an 18-hour fermentation period produced coconut oil with a yield of 29.5%, a free fatty acid content of 0.02%, and a clearer oil color. The resulting oil met the AOCS quality standards (Andaka and Arumsari, 2016). Another study found that heating at 92°C for 70 minutes produced coconut oil with a moisture content of 0.071%, free fatty acids of 0.02%, and a yield of 16.40% (Sihombing, 2017).

The aim of this study is to determine the yeast concentration and cooking time that can produce high-quality coconut cooking oil according to SNI standards. The expected benefit of this research is to identify the characteristics of coconut cooking oil produced with different yeast concentrations and cooking times. The hypothesis proposed in this study is that variations in yeast concentration and cooking time will affect the characteristics of the resulting coconut cooking oil.

2. Materials and Method

2.1 Materials

The materials used in this study include coconuts (Cocos nucifera) from Gegerkalong Market in Bandung, coconut water also from Gegerkalong Market in Bandung, Indonesia, and Fermipan yeast (PT. Sangra Ratu Boga, Jakarta, Indonesia). Additional materials used are distilled water (Smartlab, Bogor - Indonesia). Ethanol, hydrochloric acid (HCl), potassium hydroxide (KOH), chloroform, n-hexane, sodium thiosulfate, saturated potassium iodide, starch indicator, and phenolphthalein indicator, all retrieved from Merck KGaA, Germany.

Equipment

The equipment used in this study includes a coconut milk strainer, plastic containers (Lion Star, Jakarta), weighing bottles (Iwaki, Sumedang), burettes (Iwaki, Sumedang), glass funnels (Iwaki, Sumedang), Buchner funnels and vacuum apparatus (Konica Minolta, Jakarta), desiccators (Iwaki, Sumedang), Erlenmeyer flasks (Iwaki, Sumedang), beakers (Iwaki, Sumedang), measuring cylinders (Iwaki, Sumedang), incubators (Iwaki, Sumedang), filter papers (Whatman, Jakarta), clamps and stands (Iwaki, Sumedang), colorimeter (Hunter Lab, China), analytical balance (OHAUS, Shanghai, China), oven (IKA, Malaysia), pH meter (Hanna, Central Java), volumetric pipettes (Iwaki, Sumedang), dropper pipettes (Iwaki, Sumedang), spatulas, turbidimeter (Hanna, Central Java), and thermometers (PT Anugrah Putra Kencana, Bekasi).

Research Design

In this study, the production of coconut oil is carried out using a fermentation method with yeast (Saccharomyces cerevisiae), which will produce enzymes that catalyze the breakdown of protein and carbohydrate molecules in the coconut milk globules, allowing the oil molecules to come together and separate from the mixture. Variations in the concentration of the yeast and the duration of heating are used to study their effects on the characteristics of the coconut cooking oil. The experimental design employed in this research is a Factorial Randomized Block Design (RBD), consisting of two factors, each with four levels of treatment, and three replication groups, resulting in a total of 24 experiments. The treatment design in this study consists of two factors: the concentration of the yeast (A) and the duration of coconut cream cooking (t), each with 4 levels and 2 levels respectively, which are: a1, a2, a3, a4 (1%, 2%, 4%, 6%), and t1, t2 (30 and 45 minutes).

Table 1. Design of Treatment Variation of Yeast Concentration, (A) and Heating Time (T)

a_1	=	1%	t_1	=	30 minutes
a_2	=	2%	t_2	=	45 minutes
a_3	=	4%			
a_4	=	6%			

The response design conducted on coconut cooking oil includes chemical response, physical response, and organoleptic response. The chemical responses conducted on coconut cooking oil are acid number test and peroxide number test. The physical responses conducted on coconut cooking oil are total yield, color determination (colorimetry), amount of impurities, and turbidity value (turbidimetry). The organoleptic

responses conducted on coconut cooking oil are color and aroma tests (hedonic) conducted by 30 semi trained panelists.

Research Stages

The research method consists of two stages: preliminary research and main research. The preliminary research involves creating a control without adding yeast concentration, with parameters including moisture content and yield. The main research aims to determine the effect of adding yeast concentration and cooking time on the characteristics of the resulting coconut cooking oil.

2.2 Method

2.2.3 Coconut Oil Processing Using the Fermentation Method

The process for making coconut oil using the fermentation method is described as follows:

1. Separation: This step involves peeling the coconut fruit from its shell and fibers to obtain the coconut meat.
2. Grating: The coconut meat is grated to facilitate further processing.
3. Extraction and Expression: The grated coconut meat is mixed with warm coconut water (70°C) in a 1:1 ratio, then squeezed and filtered. This process is typically repeated three times (Che Man et al., 1993).
4. Filtration: The extracted and expressed mixture is filtered to separate the coconut milk from the residue.
5. Cream and Skim Separation: The coconut milk is placed in a plastic container and left to settle (decant) for 2-3 hours until it separates into two layers (cream and skim). The skim is removed by siphoning with a hose, leaving only the cream in the container.
6. Fermentation: The coconut cream obtained from the separation and decantation process is divided into closed plastic containers and then inoculated with yeast at concentrations of 1%, 2%, 4%, and 6%. The fermentation is carried out for 24 hours at room temperature (26°C).
7. Heating: The fermented cream is heated to 90°C (Che Man et al., 1993) for different durations (30 and 45 minutes) while stirring to evaporate the water and release the oil in the coconut cream.
8. Oil Filtration: The resulting oil is filtered using filter paper to separate it from the residue.
9. Oil temporary Packaging: The filtered oil is packaged into tightly sealed opaque plastic bottles.
10. Oil Analysis: The processed oil is analyzed according to the SNI parameters, including odour, colour, moisture content, acid number, and peroxide number. Additionally, tests for turbidity, colour intensity, impurity amount, and coconut oil yield are conducted.

2.2.4 Oil Yield

Oil yield can be calculated based on the weight of coconut oil obtained (g) compared to the volume of coconut milk used (g) (Sudarmadji et al., 2010).

$$\text{Oil Yield}(\%) = \frac{\text{Oil Weight (g)}}{\text{Coconut milk Weight (g)}} \times 100\ \%$$

2.2.5 Moisture Content

The moisture content test using the gravimetric method is conducted by calculating the weight loss during heating in an oven at a temperature of (105 ± 1) °C (Sudarmadji et al., 2010).

2.2.6 Acid Number

The acid number test using the volumetric method is performed by dissolving a certain amount of oil in alcohol/ether and adding phenolphthalein indicator. Then, the solution is titrated using KOH solution until a permanent change occurs (Ketaren, 1996).

2.2.7 Peroxide Number

The peroxide number test using the volumetric method is conducted by dissolving the oil in an acetate: chloroform (2:1) mixture containing KI, then titrating with sodium thiosulfate solution using starch indicator until the blue color disappears (Sudarmadji et al., 2010).

2.2.8 Turbidity Test (Turbidimetry)

Turbidimetry is a method for measuring the concentration of particulates in a suspension based on the elastic scattering of light by particles. The turbidity measurement method is based on the comparison of the intensity of scattered light to the intensity of incoming light and is measured directly (Khopkar, 2003).

2.2.9 Amount of Impurities

The test for the amount of impurities in the oil uses the results from the moisture content that has been determined by weight (Khopkar, 2003).

2.2.10 Colorimetry

Colorimetry is a color test using the CIE L*a*b* method. The instrument used is a colorimeter. The color test is carried out by placing the sample on the flat surface of the instrument up to the marked boundary. The flat surface of the reader must be completely covered to prevent light from entering and causing inaccurate readings. The colorimeter measurements result in values of lightness (L*), red/green chromaticity (a*), yellow/blue chromaticity (b*), and hue chromaticity (H*) displayed on the instrument screen (Hunterlab et al., 2008).

2.2.11 Organoleptic Test for Color and Aroma

The organoleptic test for color and aroma uses a hedonic (preference) test. The hedonic test involves 30 untrained panelists as testers. The purpose of the hedonic test is to determine the panelists' level of preference for the samples (Kartika et al., 1988). The testing scale can be seen in the following table.

Tabel 2. Hedonic Test Rating Scale

Parameter	Numeric scale
Like very much	6
Like	5
Somewhat like	4
Somewhat dislike	3
Dislike	2
Dislike very much	1

(Kartika et al., 1988).

Research Flowchart

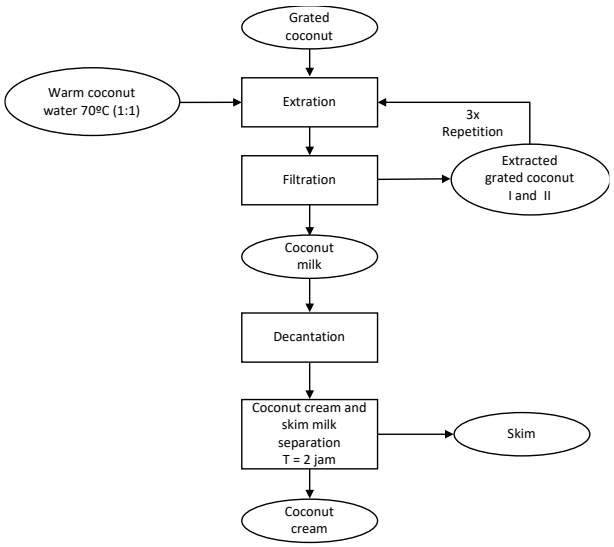

Figure 1. Flow Chart of the making of Coconut Cream.

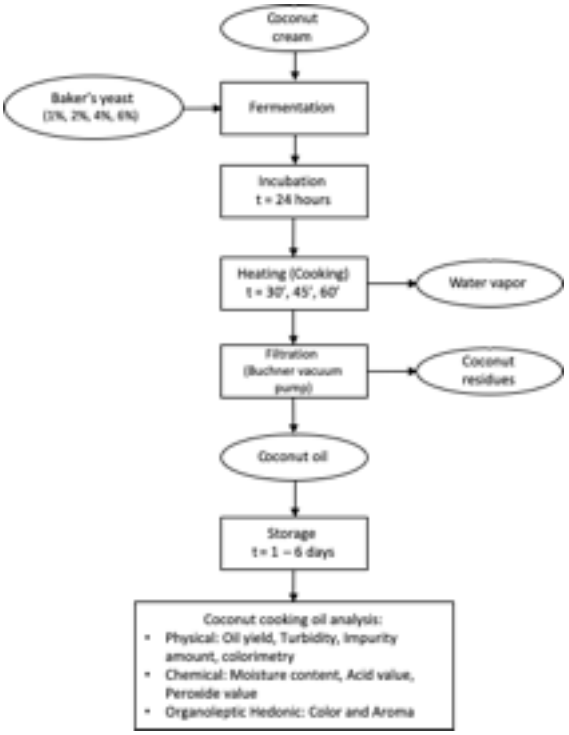

Figure 2. Main Research Flow Chart for the making and analysis of Coconut Cooking Oil

2.3 Analysis

The research data was analyzed using SPSS 2.6 with General Linear Model Multivariate analysis and presented in an Analysis Of Variance (ANOVA) table, followed by a Duncan Multiple Range post-hoc test with $P<0.05$.

3. Results and Discussion

3.1 Oil Yield

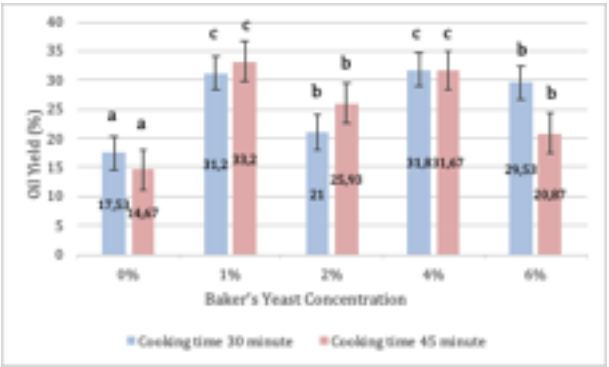

Figure 3. Oil yield (%) resulting from varying Yeast Concentration (%) and Heating Time (Minutes) Treatment

The ANOVA variance analysis results indicate that yeast concentration significantly affects ($P<0.05$) the yield of the resulting coconut oil. In contrast, neither the heating duration nor the interaction between yeast concentration and heating duration significantly impacts ($P\geq0.05$) the yield produced.

From Figure 3 it is evident that there is an increase in the oil yield compared to the control yield. This suggests that the addition of yeast concentration has a significant impact on the amount of yield produced. During the fermentation of coconut cream, adding yeast leads to the release of alcohol, organic acids, and CO_2 through the breakdown of glucose in the coconut milk. This causes the coconut milk emulsion to become unstable and undergo hydrolysis, allowing the oil to separate more easily (Mujdalipah, 2016). The highest yield of 33.2 mL was achieved with a 1% yeast concentration and 45 minutes of heating. Beyond this concentration, the results tended to decrease, although the differences were not significant. Excessive yeast concentration can result in lower yields as the microbes compete for nutrients. Once the nutrients are depleted, microbial growth ceases, reducing their effectiveness in separating the oil (Jasman et al., 2019).

In addition to the yeast concentration, the heating duration also affects the yield. Research by Sihombing (2017) indicates that higher temperatures lead to increased yields. Prolonged heating reduces the water content in the residue, enhancing heat contact with the protein, which breaks the peptide bonds and releases more oil.

3.2 Moisture Content

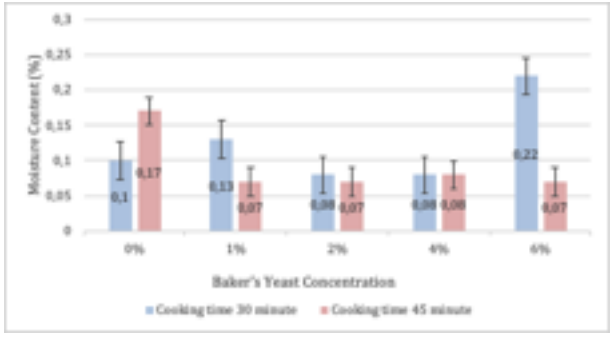

Figure I. Moisture Content (%) of cooking oil resulting from varying Yeast Concentration (%) and Heating Time (Minutes) Treatment

The results of the variance analysis indicate that the interaction between the treatment of varying yeast concentrations, cooking times, and their interaction did not significantly affect ($P\geq0.05$) the moisture content of coconut cooking oil. The moisture content analysis results show that the treated coconut cooking oil has a lower average moisture content compared to the control group. The absence of a significant effect from varying yeast concentrations suggests that the addition of yeast at an optimal concentration of 1% is effective in accelerating the breakdown of the coconut milk emulsion. The disruption of the emulsion system results in the complete separation of oil and water. The water produced during fermentation and accumulated during processing is evaporated during cooking (Kusuma et al., 2022).

The highest moisture content of 0.22% was observed with the treatment of 6% yeast concentration and 30 minutes cooking time. This is due to the incomplete hydrolysis of protein bonds in the coconut milk emulsion at a 6% yeast concentration, leading to a significant amount of water being trapped in the oil. Saccharomyces cerevisiae, the yeast added to the coconut milk, produces enzymes that break down glucose into alcohol. This alcohol helps to break the coconut milk emulsion, allowing the oil and water to separate. The enzymes produced by the yeast also convert glucose into acids, which coagulate the proteins in the emulsion system. Proteolytic enzymes act as catalysts for protein and carbohydrate molecules, facilitating the release of oil from the oil globules (Andaka & Arumsari, 2016).

Heating is performed to evaporate the water content present in the materials. The heating treatment does not significantly affect the moisture content of coconut cooking oil (Moehady & Hidayatulloh, 2020). The moisture content of the coconut cooking oil produced fluctuates between 0.07% and 0.25%. This fluctuation is likely due to the effect of heating with unstable and varying temperatures, which prevents the optimal evaporation of water from the oil.

3.3 Acid Number

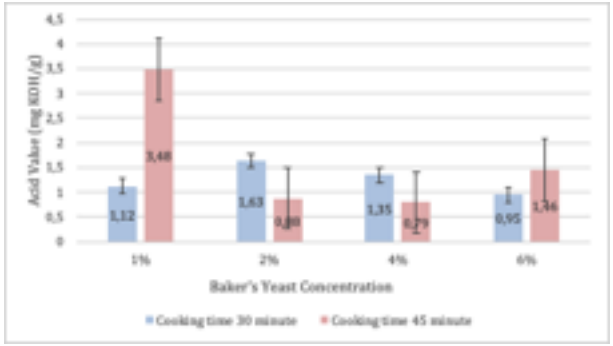

Figure 5. Acid Number of cooking oil resulting from varying Yeast Concentration (%) and Heating Time (Minutes) Treatment

The analysis of variance results indicate that the yeast concentration significantly affects ($P<0.05$)the acid number of coconut oil. In contrast, the heating duration

does not significantly affect the acid number of coconut oil (P≥0.05). However, the interaction between yeast concentration and heating duration has a significant effect (P<0.05) on the acid number.

Figure 5 shows that the obtained acid values are relatively high. Coconut oil contains free fatty acids, which increase in quantity from processing to storage. The presence of free fatty acids is an indicator of oil deterioration (F.G. Winarno, 1997). Coconut oil contains a high amount of lauric acid, which predominates. Typically, the acid number refers to the content of lauric acid within the oil. High acid values in the produced oil indicate that hydrolysis has occurred, leading to reduced oil quality. The use of baker's yeast in the fermentation process results in the formation of lipase enzymes capable of hydrolyzing neutral fats (triglycerides) into free fatty acids and glycerol. However, these enzymes are inactivated by heat (Ketaren, 1996). The applied heating treatment influences the resulting acid number. This finding aligns with research conducted by Sihombing (2017), which indicated that longer heating durations result in increased acid values, as the proteinaceous sediment (blondo) has more prolonged heat exposure, promoting fat hydrolysis and thereby increasing free fatty acid levels.

3.4 Peroxide Number

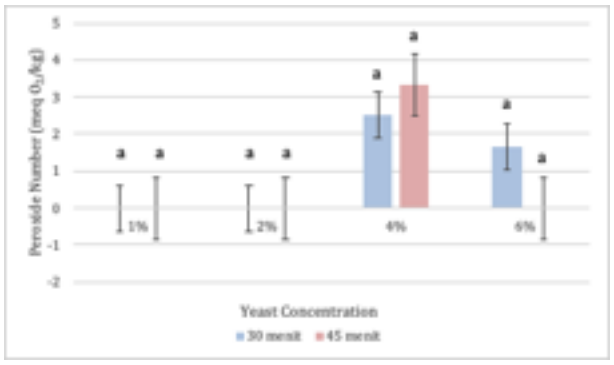

Figure 6. Peroxide Number of Oil resulting from varying Yeast Concentration (%) and Heating Time (Minutes) Treatment

The analysis of variance results show that the yeast concentration does not significantly affect (P≥0.05) the peroxide number of coconut oil, and the cooking duration also does not significantly affect (P≥0.05) the peroxide number of coconut oil. Additionally, the interaction between yeast concentration and cooking duration does not significantly affect (P≥0.05) the peroxide number of coconut oil.

Figure 6 shows that as the yeast concentration increases, the peroxide number also increases. Oil deterioration due to oxidation produces hydroperoxide and carbonyl compounds. These compounds create unpleasant odours and flavours. This likely occurs because the more yeast added, the higher the reaction rate, leading to more substrates being converted into oil. The increase in oil quantity allows for greater contact with surrounding oxygen, resulting in a higher peroxide number. Uncontrolled conditions during storage lead to undesirable results. This is supported by F.G. Winarno (1997), who states that the oxidative reaction of oil can occur due to the formation of free radical compounds, accelerated by factors such as light, heat, catalysts, metals, and enzymes.

From the research data obtained, the smallest average peroxide number is 0.00 meq O2/kg at concentrations of 1% and 2% with 30 and 45 minutes of heating, and at a 6% concentration with 45 minutes of heating, which means that all treatments of yeast concentration and heating duration meet the SNI 741:2013 standard of less than 10 meq O_2/kg.

3.5 Color L*a*b*

Table I. L*a*b*(Lightness, Redness, Yellowness) of the cooking oil treated with varying yeast concentration (%) and heating time (minutes).

Yeast concentration (A)	Heating time (T) t_1 (30 minutes)	t_1 (30 minutes)
A. Lightness, L*		
a_1 (1%)	44,68 ±0,91 Aa	41,60 ±0,43 Aa
a_2 (2%)	44,85 ±1,36 Aa	44,48 ±0,84 Aa
a_3 (2%)	45,11 ±0,05 Aa	44,88 ±0,40 Ab
a_4 (6%)	43,99 ±2,03 Aa	44,70 ±0,18 Ab
B. Redness, a*		
a_1 (1%)	-1,07 ± 0,12 Aa	0,70 ± 0,27 Bb
a_2 (2%)	-0,90 ± 0,34 Aa	-0,91 ± 0,60 Aa
a_3 (2%)	-1,29 ± 0,14 Aa	-1,08 ± 0,21 Aa
a_4 (6%)	-0,20 ± 1,04 Aa	-1,10 ± 0,02 Aa
C. Yelowness, b*		
a_1 (1%)	4,97 ± 0,31 Aa	5,03 ± 0,55 Aa
a_2 (2%)	5,82 ± 0,58 Aa	5,31± 1,05 Aa
a_3 (2%)	4,71 ± 0,46 Aa	5,51 ± 0,42 Aa
a_4 (6%)	5,85 ± 0,67 Ba	6,29 ± 0,41 Ba

The values are the average of three repetitions ± standard deviation. Values marked with the same letter in the same column indicate no significant difference at the level (<0.05), while values marked with different letters in the same column indicate a significant difference at the level (<0.05). Lowercase letters are read horizontally, and uppercase letters are read vertically.

3.5.1 L* value (Lightness)

The analysis of variance results show that both the yeast concentration and heating duration significantly affect (P<0.05) the L* value. There is also a significant interaction (P≥0.05) between yeast concentration and heating duration on the L* value of coconut oil. As yeast concentration increases, more impurities and residue are likely to form, reducing the brightness (Table 3A). Conversely, longer heating results in clearer oil as heat breaks down the emulsion, reducing non-oil fractions and producing brighter oil. Lawless & Heymann (2010) state

that light scattering is influenced by particles in the liquid; liquids that scatter more light appear brighter. The smallest L* value, 41.60, was observed with a 1% yeast concentration and 45 minutes of heating, while the largest L* value, 45.11, was seen with a 4% yeast concentration and 30 minutes of heating.

3.5.2 a* value (Redness)

The analysis of variance results show that both yeast concentration and cooking duration significantly affect ($P<0.05$) the a* value. There is a significant interaction ($P<0.05$) between these factors. Table IV shows that the a* values of the coconut oil samples are negative, indicating a tendency towards green (Table 3B). However, the oil with 1% yeast concentration and 45 minutes of heating has a positive a* value, indicating a tendency towards red. The substances in the oil tend to degrade when exposed to heat, causing the oil to turn from yellowish-brown to reddish-yellow (Ketaren, 1996). The colour observed in this study is quite good due to minimal colour degradation.

3.5.3 b* value (Yellowness)

The analysis of variance shows that yeast concentration significantly affects ($P<0.05$) the b* value, while heating duration does not significantly affect ($P\geq0.05$) the b* value. However, there is a significant interaction ($P<0.05$) between yeast concentration and cooking duration on the b* value of coconut oil. Table 3C shows that the coconut oil produced tends to be yellow. According to Ketaren (1996), the colour of coconut oil results from the reaction of carbonyl compounds from peroxide breakdown with amino acids and proteins. These compounds are oil-soluble but not water-soluble and are unstable to heat. The longer the heating duration, the more the colour compounds in the coconut oil degrade, resulting in oil that tends

3.6 Opaqueness and Impurity Content

The analysis of variance shows that neither yeast concentration nor heating duration significantly affects ($P\geq0.05$) the turbidity value of the produced coconut oil. There is also no significant interaction between yeast concentration and heating duration on oil turbidity.

Table 4. Turbidity value (NPV) and impurity content (%) of the cooking oil treated with varying yeast concentration (%) and heating time (minutes).

Yeast concentration (A)	Heating time (T) t_1 (30 minutes)	t_1 (30 minutes)
A. Opaqueness		
a_1 (1%)	4,18 ± 6,90	5,18 ± 2,70
a_2 (2%)	1,48 ± 2,57	28,18 ± 30,10
a_3 (2%)	0,00 ± 0,00	0,08 ± 0,14
a_4 (6%)	3,76 ± 1,97	1,81 ± 1,57
B. Impurity content		
a_1 (1%)	6,54 ± 0,75	4,73 ± 0,52
a_2 (2%)	5,48 ± 1,22	6,87 ± 1,40
a_3 (2%)	5,16 ± 1,76	6,61 ± 0,94
a_4 (6%)	6,99 ± 1,56	7,25 ± 0,63

3.6.1 Opaquenss

Table 4A indicates that the turbidity values of the coconut oil fluctuate due to the influence of yeast concentration and heating. The clarity of the oil is related to the number of microbes added. As the amount of yeast increases, more protein and residue result from breaking down the coconut milk emulsion, leading to higher turbidity values (Moehady & Hidayatulloh, 2020). The residues are composed of oil-soluble components such as free fatty acids, sterols, hydrocarbons, mono- and diglycerides, and colour compounds (Ketaren, 1996). Heating also affects turbidity; lower heating levels result in cloudier oil due to remaining emulsions, impacting the oil's clarity. The results show that the lowest turbidity value of 0% was obtained with a 4% yeast concentration and 30 minutes of heating.

3.6.2 Impurity Content

The analysis of variance indicates that yeast concentration does not significantly affect ($P\geq0.05$) the impurity content of coconut oil, and heating duration also does not significantly affect ($P\geq0.05$) the impurity content. There is no significant interaction ($P\geq0.05$) between yeast concentration and heating duration on the impurity content of coconut oil. Table 4B shows that higher yeast concentrations result in more impurities. Moehady & Hidayatulloh (2020) state that a higher amount of yeast increases the protein and residue formation, making it more likely for impurities to remain in the oil during filtering. Oil-soluble impurities include free fatty acids, sterols, hydrocarbons, mono- and diglycerides, and colour compounds. Colloidal suspension impurities like phospholipids, carbohydrates, nitrogen compounds, and other complex molecules can be removed by heat, sedimentation, or filtration.

3.7 Aroma and Color preference (Hedonic values)

Table 5. Hedonic values for aroma and color atribute of the cooking oil treated with varying yeast concentration (%) and heating time (minutes).

Yeast concentration (A)	Heating time (T) t_1 (30 minutes)	t_2 (45 minutes)
A. Aroma		
a_1 (1%)	4,40 ± 0,00	3,34 ± 0,15
a_2 (2%)	3,96 ± 0,34	3,82 ± 0,39
a_3 (3%)	4,26 ± 0,16	4,22 ± 0,15
a_4 (4%)	4,08 ± 0,28	4,02 ± 0,43
B. Color		
a_1 (1%)	4,63 ± 0,19	3,98 ± 0,09
a_2 (2%)	4,33 ± 0,28	4,40 ± 0,12
a_3 (3%)	4,60 ± 0,00	4,43 ± 0,12
a_4 (4%)	4,23 ± 0,36	4,49 ± 0,10

3.7.1 Aroma

The analysis of variance indicates that neither yeast concentration nor cooking duration significantly affects ($P\geq0.05$) the aroma preference of coconut oil, and there is no significant interaction ($P\geq0.05$) between these factors on the aroma preference of the produced coconut

oil. The distinctive aroma of coconut oil is naturally present and also forms due to the creation of short-chain acids when the oil deteriorates (Ketaren, 1996). The emergence of rancid smell and taste is caused by the oxidation of unsaturated fatty acid radicals in the oil, which can be accelerated by factors such as light, heat, metals, and enzymes. The hydroperoxide compounds formed are unstable due to these factors, breaking down into volatile compounds like fatty acids, aldehydes, and ketones, which cause unpleasant odours in the oil (F.G. Winarno, 1997).

Table 5A shows that the lowest aroma attribute score was 3.34 for a 1% yeast concentration with 45 minutes of heating, which falls into the "slightly dislike" category, and the highest score was 4.40 for a 1% yeast concentration with 30 minutes of heating, falling into the "slightly like" category. The distinctive aroma in coconut oil, caused by nonyl methyl ketone, tends to be preferred by panellists (Ketaren, 1996).

3.7.2 Color

The analysis of variance shows that yeast concentration and heating duration do not significantly affect ($P \geq 0.05$) the colour hedonic value of coconut oil, but there is a significant interaction ($P<0.05$) between yeast concentration and heating duration on the colour preference. Table 5B shows that the results are relatively consistent. The yeast concentration of 1% with 30 minutes of heating is preferred, with a higher preference score of 4.63. The oil colour results from colour compounds and other impurities present in the oil. The browning of the oil containing protein and carbohydrates is not due to natural pigments but to the Maillard reaction, which occurs between carbonyl compounds from peroxide breakdown and amino acids and proteins at high temperatures (Muchtadi et al., 2010).

The study results show that the lowest colour preference score was 3.98 for a 1% yeast concentration with 45 minutes of heating, falling into the "slightly dislike" category. The highest score was 4.63 for a 1% yeast concentration with 30 minutes of heating, falling into the "somewhat like" category.

3.8 Best Treatment

The best treatment was determined using the De Garmo method by evaluating the Productivity Value (PV) produced (data not shown). The best treatment was obtained with a yeast concentration of 1% and a heating duration of 30 minutes, as indicated in Table 6.

In a comparison of coconut oil tested as additional research data, the coconut oil selected from the best treatment had a better quality in terms of moisture content, with a value of 0.13%, compared to commercial oil with 0.2%. The acid number from the research was 1.12 mg KOH/g, while the commercial oil had 1.17 mg KOH/g (Table 7). The other coconut oil used for comparison was traditional commercial coconut oil from Tasikmalaya. When compared to the quality requirements of coconut oil based on the Indonesian National Standard (SNI), the coconut oil from the best treatment falls into the category of grade II coconut cooking oil for moisture content (Table 7) and grade I coconut cooking oil for acid number (Table 7).

Tabel 6. Compilation of Physical and Chemical Characterization of of the cooking oil treated with varies yeast concentration (%) and heating time (minutes).

Parameter	0% Yeast		1% Yeast		2% Yeast		4% Yeast		6% Yeast	
	30'	45'	30'	45'	30'	45'	30'	45'	30'	45'
Rendemen (%)	0,81	2,08	31,20	33,20	21	25,93	31,8	31,67	29,53	20,87
Kadar Air (%)	0,1	0,17	0,13	0,07	0,08	0,07	0,08	0,08	0,22	0,07
Angka Asam (mg KOH/g)	-	-	1,12	3,48	1,63	0,88	1,35	0,79	0,95	1,46
FFA sebagai asam laurat (%)	-	-	0,33	1,24	0,58	0,31	0,48	0,28	0,34	0,51
Angka Peroksida (mek O_2/kg)	-	-	0	0	0	0	2,5	3,33	1,66	0
Zat Pengotor (%)	-	-	6,54	4,73	5,48	6,87	5,16	6,61	6,99	7,25
Kekeruhan (%)	-	-	4,18	5,18	1,48	28,18	0	0,08	3,76	1,81
Warna CIE L*	-	-	44,68	41,6	44,85	44,48	45,11	44,88	43,99	44,7
Warna CIE a*	-	-	-	0,70	-	-	-	-	-	-
Warna CIE b*	-	-	1,07		0,90	0,91	1,29	1,08	0,20	1,10
Hedonik Warna	-	-	4,97	5,03	5,82	5,31	4,72	5,51	5,85	6,29
Hedonik Aroma	-	-	4,63	3,98	4,33	4,4	4,6	4,43	4,23	4,49
			4,44	3,33	3,94	3,82	4,26	4,22	4,08	4,02

Tabel 7. Compilation of Physical and Chemical Characterization of of the cooking oil treated with varying yeast concentration (%) and heating time (minutes).

Parameters	Treatment 1% Yeast & 30' heating time	Coconut cooking oil Traditional commercial	SNI Coconut cooking oil Grade I	SNI Coconut cooking oil Grade II	SNI Coconut oil
Oil yield (%)	31,20	-			-
Moisture content (%)	0,13	0,2	maks 0,1	maks 0,3	maks 0,3
Acid value (mg KOH 0,1N/g)	1,12	1,17	maks 0,6	maks 2	-
FFA* as lauric acid (%)	0,33	0,42	-	-	maks 0.1*
Peroxide value (meq O_2/kg)	0	0	-	-	maks 5
Impurities (%)	6,54	5,03	-	-	-
Turbidity (%)	4,18	0	-	-	-
Color CIE L	44,68	42,7	-	-	-
Color CIE a	-1,07	-0,62	-	-	-
Color CIE b	4,97	6,46	-	-	-
Hedonic of Color	4,63	-	-	-	-
Hedonic of Aroma	4,44	-	-	-	-

*FFA: Free fatty acid

4. Conclusion

Yeast concentration affects the acid number, with the optimum value at 4% concentration being 0.79 mg/KOH. The yield has an optimum value of 33.20% at 1% concentration. The brightness level (L*) is optimal at

4% concentration with a value of 45.11, the redness level (a*) is optimal at 6% concentration with a value of -1.29, and the yellowness level (b*) is optimal at 6% concentration with a value of 6.29.

Heating duration influences the brightness level (L*), with the optimal treatment being 4% concentration and 30 minutes, yielding a value of 45.11. The redness level (a*) is optimal at 4% concentration and 30 minutes with a value of -1.29. The yellowness level (b*) is optimal at 6% concentration and 45 minutes, yielding a value of 6.29.

Using the De Garmo method, the best results were obtained with a 1% yeast concentration and 30 minutes of heating, yielding 31.20%, moisture content of 0.13%, free fatty acid content as lauric acid at 0.33%, and a brightness level (L*) of 44.68. Overall, fermenting coconut oil with yeast improves the quality of the oil compared to the control results. This method provides an easier, more efficient, and high-quality alternative for producing coconut cooking oil.

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