RED ONION (*Allium ascalonicum*) PEEL EXTRACT AS A NATURAL SOURCE OF ANTIOXIDANTS TO ENHANCE THE OXIDATION STABILITY OF *REFINED BLEACHED DEODORIZED PALM OIL* (RBDPO)

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ABSTRACT

The repeated use of cooking oil can trigger chemical reactions that cause the cooking oil to be unstable to heat. Red onion peel may be an antioxidant because it contains flavonoid compounds, polyphenols, saponins, and alkaloids that scavenge free radicals. This study aims to prove the use of natural antioxidant concentrations of onion peel. This study used a completely randomized design (CRD) consisting of 5 treatments of onion peel extract, namely 3% (P1), 6% (P2), 9% (P3) 12% (P4), without treatment (P-), and the addition of 0,1% BHT (P+) with consecutive times. The ability of antioxidant of onion peel extract is known to be able to maintain the stability of cooking oil compared to an antioxidant synthetic BHT. Peroxide in extract oil 9% (6.65 meq/kg), Total Oxidation in extract oil 9% (15.92 meq/kg), P-anisidine in extract oil 3% and 9% (3.54 meq/kg) /kg and 3.92 meq/kg) and the iodine value of the extract oil 3%, and 9% (21.41 mg iodine/g and 20.81 mg iodine/g). It was found that natural antioxidants of onion peel extract showed better primary oxidation inhibition ability than synthetic antioxidants BHT and among the five types of antioxidant concentrations, antioxidants from onion peel extract 9% showed the best oxidation inhibition ability. So that it can be obtained that the addition of onion peel extract is used as a natural antioxidant to maintain the stability of the oil against heat

Keywords: Antioxidant; FFA; Onion Peel; Peroxide

INTRODUCTION

Cooking oil can be damaged with prolonged use and repeated use. The use of high temperatures (160-180 °C) when frying and contact between oil, water, and air can cause an oxidation reaction that forms free fatty acids (Patty *et al*., 2017). The hydrolysis process causes free fatty acids in cooking oil, which occurs during the frying process (Faridah *et al*., 2013; Roslan *et al*., 2021; Shafidzah *et al*., 2022) Oxidation reactions can produce toxic products and harm health (Quaresma *et al*., 2021). One way to inhibit and prevent oxidation reactions is the addition of antioxidants. However, according to the Panagan (2010), synthetic antioxidants can cause adverse effects on human health, such as impaired liver, lung, intestinal, and poisoning functions. Katrin and Bendra (2015) reported that antioxidants BHA and BHT could cause tumors in experimental animals in long-term use. Even in some developed countries, such as Japan and Canada, the use of synthetic antioxidants such as BHA, BHT, and TBHQ has been banned (Ayucitra *et al*., 2011).

One of the potential sources of antioxidants is onion peel. According to Siswati *et al*. (2016) onion peel extract has a reasonably strong antioxidant activity in inhibiting the process of rancidity of coconut oil, and this can be seen in the best test results obtained a concentration of 11% red onion peel extract, which has been extracted with a time of 1.5 hours. Compared to other extraction times (0.5 hours, 1 hour, 2 hours, and 2.5 hours) and other extract concentrations (3%, 5%, 7%, and 9%), 11% onion peel extract with an extraction time of 1,5 hours resulted in the most effective in suppressing the increase in the peroxide value of the oil. A similar study was also conducted by Shidiq *et al*. (2018) regarding the effect of adding onion extract (*Allium ascalonicum L*) on the peroxide value of palm cooking oil, which was used repeatedly. Another study (Patty *et al*., 2017) is that using plantain peels as natural antioxidants can reduce free fatty acid levels in used cooking oil. In the research of Guo *et al*. (2016), the use of antioxidants in rosemary extract proved to improve the quality of RBDPO oil. Meanwhile, onion peel extract has never been tested on RBDPO oil. Therefore, RBDPO oil was used to see the performance of the single effect of onion peel extract because in RBDPO oil, there was no commercial antioxidant addition as in cooking oil, so it can be used as the object for testing the role of onion peel as an antioxidant. Furthermore, if the onion peel extract can improve the oil's quality, it can potentially be used as a substitute for synthetic antioxidants in commercial oils. This is based on the research of Siswati *et al*. (2016), which stated that onion peel was able to increase the oxidative stability of the oil.

The red onion peel used has a red color and dry peel characteristics. Red onion peel extract contains compounds that are potential antioxidants, namely flavonols from the flavonoid group. Flavonol itself belongs to the flavonoid group that has antioxidant activity, in addition to flavones, isoflavones, catechins, and chalcones. Flavonols in red onion accounted for 38.2 mg/kg (Fieschi *et al*., 1989). Patty *et al*. (2017) stated that natural antioxidants from the flavonoid and phenolic groups could reduce free fatty acids (FFA) in used cooking oil. The results of another study conducted by Rodrigues *et al*. (2011) showed that the content of flavonoid compounds of the flavonol type in shallots was 304.3 mg/kg. Furthermore, the addition of 11% red onion peel extract could prevent the rancidity of coconut oil (Siswati *et al*., 2016). Based on previous research conducted by Siswati *et al*. (2016), natural antioxidants of flavonols in onion peel extract to prevent the process of rancidity of coconut oil by testing the peroxide level of coconut oil showed the results that the onion peel contains antioxidants that are strong enough to inhibit the process rancid of coconut oil.

There has been no research on reducing free fatty acid levels, peroxide value, p-anisidin number, total oxidation, acid number test, saponification, iodine number, and color intensity using natural antioxidants from red onion peel waste and tests related to the activity. In Indonesia, there were 1.815.445 tons in 2020 (BPS, 2020), and 10% of the onion is the waste peel of the red onion (DKPI, 2018). Therefore, red onion peel has a high potential to be a source of antioxidants if it is known to be able to enhance the stability of RBDPO oil. Antioxidants and testing the effectiveness of natural and synthetic antioxidants in improving oil quality by reducing the damage parameters of used cooking oil such as free fatty acid number, oxidation number, and peroxide value. Therefore, in this study, a test was carried out on the effectiveness of natural antioxidants in onion peel extract, which was thought to inhibit the oxidation reaction in palm oil. To support research on the effectiveness of natural antioxidants of red onion peel on RBDPO oil, a comprehensive evaluation of the antioxidant effect of ethanolic extract of onion peel on palm oil was carried out.

METHOD

Red onion (*Allium ascalonicum L.*) peel was obtained from the waste of Pasar Besar Malang with the characteristics red and dry peel, aquades, Refined Bleached Deodorized Palm Oil (RBDPO) oil obtained from PT. Wilmar Group, BHT, alcohol, PP indicator, starch indicator, Na-thiosulfate 0.1 N (Merck®), HCl 0.5 N (Merck®), KOH 0.1 N (Merck®), KOH 0.5 N (Merck®), anisidine (Merck®), isooctane (Merck®), glacial acetic acid (Merck®), HCl (Merck®), KI (Merck®), saturated KI, and chloroform (Merck®). The tools used in this study include a cabinet dryer, waterbath shaker (Memmert), measuring cup, stirring rod, filter paper, analytical balance (Ohaus PX224/E), beaker glass (Pyrex), Erlenmeyer (Pyrex), a set of titration tools, dropper pipette, measuring pipette, dark bottle, color reader (Konica Minolta CR-10 Plus), UV spectrophotometry (BEL UV-51), vortex, and rotary evapotaror (IKA RV 10).

Red Onion Peel Extraction (Wang *et al.*, 2017)

The onion peel is pulverized until it becomes red onion peel powder. Onion powder was soaked in 80% ethanol (1:20). Onion peel filtrate was filtered. The obtained filtrate was evaporated to remove the ethanol solvent.

Cooking Oil Characterization Analysis

The experimental design in this study was a simple Completely Randomized Design (CRD) with variations in the concentration of onion peel extract. Application of onion peel extract to oil (Wang *et al.*, 2017), Analysis of the characteristics of cooking oil, including peroxide value (AOCS Cd 8-53, 1997), p-anisidin number (IUPAC, 1987), total oxidation (AOCS, 1997) and free fatty acid (FFA) (AOCS Ca 5a-40, 1997), total oxidation (AOCS, 1997), Acid Number Test (AV) (AOCS, 1998), saponification (Putri *et al.*, 2021), Iodine number (Hutami and Ayu, 2015), Density Analysis (Rahim, 2017), and Color Intensity (Munsell, 1997).

Applying Onion Peel Extract to Cooking Oil (Wang *et al.*, 2017)

Cooking oil is mixed with onion peel extract with varying percentages. The percentage of onion peel extract used included 3% (P1), 6% (P2), 9% (P3), and 12% (P4), and 100 ml of cooking oil was used without the addition of onion peel extract (P-) and 100 ml of onion peel extract. Ml of cooking oil with the addition of 0.01% BHT (P+) as a comparison. This mixture is then in the oven at 60 °C for 24 hours to accelerate the breakdown of the oil. The mixture of cooking oil with ethanolic onion peel extract was then analyzed for the physical and chemical properties of the oil.

Peroxide Value Analysis (AOCS Cd 8-53, 1997)

Peroxide number analysis was carried out by titration method using $Na_2S_2O_3$. The sample was weighed 5 g and added 30 ml of acetic acid and homogenized chloroform (3:2), added 0.5 ml of saturated KI solution, stored in a dark place for 2 minutes, then added 30 ml of distilled water and four drops of starch solution with a concentration of 1%. The solution obtained was then titrated with 0.05 N $Na_2S_2O_3$ until it was clear.

p-anisidin Number Analysis (IUPAC, 1987)

Adding 1 g of sample and 25 ml of isooctane, then measure the absorbance at a wavelength of 350 nm using a UV-VIS spectrophotometer. Then 5 ml of the solution was taken, and 1 ml of 0.25% p-anisidin was added in glacial acetic acid. After that, close the test tube, homogenize, and store in a dark place for 10 minutes, and measure at a wavelength of 350 nm as absorbance.

Total Oxidation Analysis (AOCS, 1997)

The total oxidation test was obtained by adding two times the peroxide number plus the p-anisidin value.

Free Fatty Acid (FFA) (AOCS Ca 5a-40, 1997)

FFA levels were tested using the (AOCS Ca 5a-4) method, in which 2 g of the sample was dissolved in 50 ml of heated 95% ethanol solvent. Then the solution obtained was added 5 drops of PP indicator and stirred for 30 seconds. Then the titration was carried out with 0.1 N NaOH. The titration process was stopped if there was a change in the color of the solution to pink for not less than 30 seconds.

Acid Number (AOCS, 1997)

Acid number testing was carried out based on the AOCS Ca 5a-40 method. The acid number is determined by the KOH titration method in the sample solution, with the principle of the amount of KOH required (mg) to neutralize 1 g of fat.

Saponification number (AOCS Cd 3-25, 1997)

The sample was weighed as much as 1.5-5 g and then mixed with 50 ml of 0.714 M KOH solution (40 g of KOH in 1 liter of alcohol). Then, cover in the refrigerator and simmer for 30 minutes. After that, the sample was cooled, and the pp indicator was added, and then the excess KOH was titrated with a standard solution of 0.5 N HCl. Blanks were made by adding 50 ml of KOH (without oil), heated to boiling, and then cooled. KOH is titrated with 0.5 N HCl solution until a pink color change occurs.

Iodine Number Test (Hutami and Ayu, 2015)

0.2 g of sample added 20 ml of chloroform and 25 ml of wijs, then homogenized. The sample was then reacted for 1 hour in a dark room. Then, 20 ml of 15% KI and 100 ml of distilled water were mixed until the sample turned dark in color. After that, the solution is titrated with 0.1 N Na_2SO_3 solution with starch indicator until the titrate is clear.

Density Analysis (Rahim, 2017)

Density analysis in this study using a pycnometer. The empty pycnometer and the pycnometer filled with fluid are weighed, and the difference between the weights is compared with the volume pycnometer.

Color Intensity Test (Munsell, 1997)

The color reader is turned on by pressing the power button. The sample is placed under a color reader lens, then the color intensity values of L (Lightness), a*, b*, C (Chroma), and H (Hue) samples are read.

Statistic Analysis

The results of the analysis of the physicochemical properties of the oil were analyzed statistically (ANOVA) using SPSS 25 software and then further tested using the DMRT method with a 5% confidence level.

RESULTS AND DISCUSSION

Peroxide

The addition of onion peel extract with different concentrations had a significant effect ($p<0.05$) on the peroxide value of cooking oil. The highest peroxide value was found in the oil treatment without the addition of onion peel extract, which was 30,00 meq/kg, while the lowest peroxide value was found in cooking oil with the addition of 9% onion peel extract, which was 6,65 meq/kg (Table 1). This shows that natural antioxidants can inhibit oxidation reactions and work more effectively than synthetic antioxidants BHT. According to Sallis (2014) the increase in the peroxide number can be caused by the dissolution of the double heating temperature.

The antioxidant of onion peel extract 9% showed the best ability to inhibit oxidation. The ethanol extract of onion peel has a reasonably high percentage value of inhibition against DPPH radicals, namely 77% (preliminary research data). Oil with the addition of 6% and 12% extract increased the oil's peroxide value. The high concentration of antioxidants will cause the oil to become a prooxidant. Prooxidants come from antioxidants that accumulate in high concentrations. The amount of added antioxidant concentration can affect the rate of oxidation. At high concentrations, the antioxidant activity of phenolic groups often disappears and can even become prooxidants (Gordon, 1990). When the dose of antioxidants and prooxidants is not balanced, or the antioxidant levels are high. In contrast, the prooxidants are low, and they would form prooxidant compounds to balance the levels with antioxidants, which would make the free radical cells irreparable and affect the level of antioxidant oxidation oil. The synthetic antioxidant BHT has a labile hydrogen atom in the hydroxyl group which can donate and reduce the free radicals present in the oil at the initiation of lipid oxidation. Thus, the synthetic antioxidant BHT will be oxidized, and the remaining radicals will be stabilized by the electrical dislocation of the benzene ring. Synthetic antioxidant BHT can also function as a quencher (extinguisher) for singlet oxygen and has good ability against radicals (Akhlus and Herawati, 2006), and is resistant to heating processes (Berry, 2003). Thus, BHT has considerable potential as an alternative antioxidant to expand the use of RBD palm oil.

Table 1. Physicochemical Test Results of Cooking Oil

Treatments	Peroxide (meq/kg)	P-ansidine (meq/kg)	Total Oxidation (meq/kg)	FFA (%)	Acid Number (mg KOH/g)
BHT 0.01%	17.29 ± 1.29 [d]	4.99 ± 2.77 [a]	39.57 ± 4.47 [b]	0.01 ± 0.00 [b]	0.00 ± 0.00 [a]
0%	30.0 ± 4.00 [e]	7.23 ± 3.99 [a]	67.23 ± 11.23 [c]	0.02 ± 0.01 [b]	0.01 ± 0.02 [a]
3%	9.96 ± 0.04 [ab]	3.54 ± 3.00 [a]	23.46 ± 3.03 [a]	0.01 ± 0.04 [b]	0.00 ± 0.00 [a]
6%	13.81 ± 1.92 [cd]	6.57 ± 2.04 [a]	34.19 ± 3.53 [b]	0.00 ± 0.00 [a]	0.00 ± 0.02 [a]
9%	6.65 ± 1.52 [a]	3.92 ± 1.32 [a]	15.92 ± 4.30 [a]	0.00 ± 0.00 [a]	0.00 ± 0.00 [a]
12%	12.46 ± 0.54 [bc]	18.52 ± 3.18 [b]	43.44 ± 4.26 [b]	0.00 ± 0.00 [a]	0.00 ± 0.00 [a]

Note: Data shown are the means ± standard deviation. Different superscript letters in the same column indicate a significant difference ($p<0.05$)

The addition of antioxidants in cooking oil aims to inhibit the rate of oxidation. Primary antioxidants (AH) can give hydrogen atoms quickly to lipid radicals (R•, ROO•) and convert them to more stable forms, while the antioxidant radical derivatives (A•) have a more stable state than lipid radicals (Trilaksani, 2003). The addition of primary antioxidants (AH) with low concentrations of lipids can inhibit or prevent the autoxidation reaction of fats and oils. The addition can block the oxidation reaction at the initiation and propagation stages. The antioxidant radicals (A•) formed in this reaction are relatively stable and do not have enough energy to react with other lipid molecules to form new lipid radicals. Antioxidant radicals can react with each other to form non-radical products.

Based on SNI No. 3741:2013 concerning cooking oil (2013), the maximum peroxide value for cooking oil is ten meq/kg. The measurement of the peroxide number in the oil sample with the addition of 9% red onion peel extract showed that the cooking oil had met the SNI quality standard for cooking oil which indicated that the quality of the oil was still well maintained. Siswati *et al.* (2016) stated that the higher the concentration of onion peel extract added to the oil, the oil with the lowest peroxide number will be obtained, this is because the principle of antioxidants prevents or stops the oxidation process by neutralizing oxygen to prevent the formation of peroxides or capture compounds that can cause oxidation ionizes the formation of peroxides by removal of hydrogen.

This study showed that for the peel of red onion which humans do not usually use, there is a water fraction containing flavonoids, polyphenols, saponins, terpenoids, and alkaloids that can act as antioxidants. For example, the flavonoid compounds contained in the ethyl acetate fraction of onion peel extract are the flavonol group, a natural antioxidant type (Rahayu *et al.*, 2015). Furthermore, based on research conducted by Purwaningsih *et al.* (2019), plantain peel extract improved the quality of bulk cooking oil by decreasing the peroxide number, acid number and increasing the iodine number. These results are in line with previous studies that natural antioxidants from onion peel extract can inhibit the rancidity of coconut oil (Siswati *et al.*, 2016) and cooking oil with repeated use (Shidiq *et al.*, 2018).

Red onion peels contain flavonoid compounds that act as antioxidants and are often used as a deterrent (Rohmawati *et al.*, 2017). The results of this study are in line with Siswati regarding the use of natural antioxidants flavonols to prevent the process of rancidity in oil and show the results that coconut oil that has been given 11% onion peel extract shows a lower peroxide value, which is 0.6144 meq/kg which is better than the results of this study. In this study the concentration of 9% is the best concentration which produces a peroxide number of 6.65 meq/kg. This is because in coconut oil the composition of the largest fatty acid constituent is oleic fatty acid, while the RBDPO oil is palmitic fatty acid. This is supported by the statement of Putri *et al*. (2020) oleic acid which is an unsaturated fatty acid that has a single double bond (MUFA) so that the oil is more stable than other unsaturated fatty acids that have more double bonds (PUFA).

In addition, Soebagio *et al.* (2007) reported that onion peel extract contains chemical compounds that have the potential as antioxidants, namely polyphenols, that can prevent the development of free radicals. Antioxidants are substances that can delay or prevent free radical antioxidant reactions in lipid oxidation (Kochhar and Rossell, 1990). Antioxidants can also inhibit the process of rancidity because antioxidants are more reactive than oxygen. Therefore, the active molecules of antioxidants prevent the formation of peroxides by binding to oxygen—the mechanism of action of antioxidants through two functions. The first function is the primary function of antioxidants, namely as a hydrogen atom donor. The second function is a secondary function of antioxidants, namely slowing the rate of autoxidation by various mechanisms other than breaking the autoxidation chain by converting lipid radicals to a more stable form (Gordon, 1990; Siswati *et al*., 2016).

P-anisidin Value

The lowest p-anisidin number was found in the oil with the addition of 3% and 9% onion peel concentrations in (Table 1), namely 3.54 meq/kg and 3.92 meq/kg, respectively. Compared with synthetic antioxidants BHT, the use of natural antioxidants 3% and 9% resulted in lower p-anisidin numbers than BHT. BHT has good activity against radicals (Akhlus and Herawati, 2006; The Merck Index, 1984) and is quite resistant to heating (Berry, 2003). Therefore, BHT has enormous potential as an alternative antioxidant used to expand RBD palm oil. Meanwhile, based on research (Rahayu *et al*., 2015), it is known that the onion peel extract with water fraction contains flavonoid compounds, polyphenols, saponins, alkaloids, and terpenoids. Flavonoids are natural phenolic compounds that have the potential as antioxidants.

The insignificant increase in p-anicidin numbers at 9% and 12% concentrations was because p-anicidin numbers only measured 2-alkenal and 2,4-dinal compounds that were not correlated with nonanal Tompkins and Perkins, (1999). Nonanal was the first aldehyde to be formed from the decomposition of oleic acid. Good quality oil should have a p-anisidin value below 20 mEq/Kg (Hamilton *et al*., 1998). According to Anderson *et al*. (2020), the parameter of cooking oil quality, in general, is p-Anisidine Value (p-AnV) maximum 6. The peroxide number can influence the anisidine number. Feryana *et al*. (2014) stated that the anisidin number was influenced by the high content of hydroperoxide compounds in the primary oxidation process in the form of aldehydes and ketones.

Red onion peel contains flavonol compounds, a group of flavonoids, a type of yellow pigment that has antioxidant properties that act as free radical acceptors (Siswati *et al*., 2016). This ability is strongly suspected of causing the decrease in oxidation products, which is reflected in the oil's low value of oxidation parameters, such as the anisidine number.

Total Oxidation

The total oxidation value is an indicator of the overall oxidation of the oil, which is a combination of the peroxide number and the anisidin number. In accordance with Suseno *et al*. (2011) statement which states that total oxidation or TOTOX is a parameter obtained from adding twice the peroxide number to the p-anisidin number. The highest oxidation value of the oil was found in the treatment without the addition of antioxidants (control) which was 67.23 meq/kg, and the lowest oxidation value was at a concentration of 9% (Table 1). Antioxidants can stop the process of cell damage by donating electrons to free radicals. Antioxidants will neutralize free radicals so that they no longer have the power to take electrons from cells and DNA. If an oil does not contain antioxidants, the active peroxide will react with the double bonds of fat. If an antioxidant is added, the active peroxide will react with the antioxidant, and free radicals can be stopped. The high value of total oxidation in oil without adding antioxidants is due to the absence of antioxidant compounds that can inhibit the oxidation process. The total oxidation value (TOTOX) for edible oil is between 10-60 meq/kg (Bimbo, 1998). Meanwhile, IFOS states that edible oil must have a TOTOX value below 20 meq/Kg.

Free Fatty Acids (FFA)

The standard of free fatty acids (FFA) in cooking oil is a maximum of 0.3% (SNI-3741-1995). This shows that ALB cooking oil in all treatments still meets SNI standards. The ANOVA results showed that adding onion peel extract at various concentrations had a significant effect ($P<0.05$) on ALB oil. The addition of onion peel extract 6%, 9%, and 12% was more effective in inhibiting FFA formation after heating than the treatment oil with the addition of 3%, 0%, and 0.01% BHT (Table 1). This is because the red onion peel extract contains flavonol antioxidant compounds that can withstand increased levels of free fatty acids. The higher levels of free fatty acids indicate that the quality of the oil has decreased (Panagan, 2010). ALB is formed due to the hydrolysis reaction of triglycerides which results in broken fatty acid and glycerol bonds and is also caused by splitting and oxidation of fatty acid double bonds (Deepika *et al*., 2014). Free fatty acids are one of the indicators in determining the quality of the oil. The worse the quality of fish oil, the greater the value of free fatty acids (Eka and Rochima, 2016).

Natural antioxidant compounds from onion peel extract are multifunctional and can act as reducers, free radical scavengers, metal chelators, and reduce the formation of singlet oxygen. In addition, natural antioxidants inhibit chemical oxidation reactions that can damage macromolecules and cause various health problems and add nutritional content to cooking oil (Ayucitra *et al*., 2011).

Acid Number

The addition of synthetic antioxidants and natural antioxidants of onion peel extract had no significant effect on the acidity value of the oil ($p>0.05$). According to Widayat (2006) the acid number of oil is equivalent to its free fatty acid content. This is because many triglycerides have been decomposed into free fatty acids due to hydrolysis reactions. The results showed that synthetic antioxidant BHT still produced an insignificant acid number compared to the addition of onion peel extract at all concentrations. This result is not in line with research Nurdianti *et al.* (2017), where the concentration of added antioxidants has a significant effect on acid number. The higher the acid number can affect the quality of the oil. The higher the value of the acid number, the lower the quality of the oil. The results showed that all treatments were under the SNI standard, namely 0.06 mg KOH/g. The quality of the oil decreases as the acid number increases. According to SNI, the acid number is expressed by the amount of KOH in mg needed to neutralize 1 g of FFA. Acid number is a parameter to determine the components of acids other than fatty and the presence of FFA. Freshness of raw materials and composition of oil affect the acid number of an oil (Bura Mohanarangan, 2012).

Saponification Number

The addition of synthetic antioxidants and natural antioxidants of onion peel extract had no significant effect on the saponification rate of the oil ($p>0.05$).

According to the Indonesian National Standard (SNI) No. 01-3741-2002, the saponification of cooking oil ranged from 196-206 mg KOH/g oil. The test results (Table 2) show that the highest saponification number is in oil with 3% onion peel extract, 26.94 mgKOH/g, while the lowest saponification number is in oil with oil the addition of synthetic antioxidant BHT, which is 14.30 mgKOH/g. The difference in yield can be influenced by the molecular weight of the oil Seneviratne and Jayathilaka (2016) and the molecular weight is influenced by the type of fatty acid that is dominant in the oil.

According to Hermanto *et al*. (2008), differences in fatty acid composition (short, medium, and long chains) will significantly affect the value of the saponification number.

Table 2. Physicochemical Characteristic of Cooking Oil

Treatments	Saponification Number (mg KOH/g)	Iodine Number (mg Iod/g)	Density (g/cm^3)
BHT 0.01%	181.70 ± 2.87 ^{a}	34.56 ± 0.38 ^{b}	1.02 ± 0.05 ^{b}
0%	189.64 ± 6.20 ^{a}	32.89 ± 0.10 ^{b}	1.01 ± 0.01 ^{a}
3%	189.69 ± 12.57 ^{a}	21.41 ± 0.47 ^{a}	1.01 ± 0.05 ^{ab}
6%	189.73 ± 7.32 ^{a}	31.47 ± 4.68 ^{b}	1.03 ± 0.05 ^{b}
9%	194.59 ± 17.77 ^{a}	20.81 ± 5.77 ^{a}	1.02 ± 0.00 ^{ab}
12%	195.70 ± 14.49 ^{a}	29.48 ± 1.60 ^{b}	1.02 ± 0.01 ^{ab}

Note: Data shown are the means ± standard deviation. Different superscript letters in the same column indicate a significant difference (p<0.05)

Iodine Number

The addition of onion peel extract at various concentrations had a significant effect (P<0.05) on the iodine number of the oil. The best oil with the addition of antioxidants in red onion peel extract was at concentrations of 6% and 12%. This is in accordance with the research of Siswati *et al*. (2016) where the concentration of 11% onion peel extract is the best treatment in maintaining the quality of coconut oil. Meanwhile, the lowest iodine number was in oil with a concentration of 3% and 9% shallot skin, which was 21.41 mg Iod/g and 20.81 mg Iod/g. This is supported by research by Guo *et al*. (2016) that low concentrations of antioxidants result in low iodine numbers because the contact between antioxidants and oil decreases and is unable to maintain oil quality. The results of this study are in line with research by Rejeki (2019), where the iodine value is higher in coconut oil added with purple sweet potato leaf extract as a source of natural antioxidants compared to the oil without the addition of antioxidants. This is because the addition of antioxidants acts as an inhibitor of the oxidation process in the oil so that the content of unsaturated fatty acids in coconut oil is still a lot and results in much iodine being absorbed.

Therefore, the iodine number becomes high. Meanwhile, coconut oil as a control had a lower iodine value. This is because the oil undergoes an oxidation reaction, namely the severance of the double bond in the unsaturated fatty acid by oxygen so that the unsaturated fatty acid contained in the oil becomes less and causes the iodine number to decrease. According to Khamdani *et al.* (2011), the low iodine number indicates that the oil has low unsaturated fatty acids. This also proves that the number of double oil bonds will decrease. Iodine value is inversely proportional to the value of FFA (Free Fatty Acid) levels. The higher the FFA content of the oil, the lower the iodine value of the oil. From the five treatments, the oil still met the quality requirements set by the SNI (2006) namely 50-55 mgIod/g.

Density

The results of the analysis of variance showed that the addition of onion peel extract at various concentrations had a significant effect (P<0.05) on the oil density value (Table 2). The density of good cooking oil is 860–910 kg/m^3 (Warsito *et al*., 2013). This is not under the test results, where the table shows that all treatments are >1.000 kg/m^3. Another study conducted Rusdiana (2015) on new cooking oil resulted in a density of 925 kg/m^3 and 1-time use of 923 kg/m^3. Compared with the test results, the oil that has been heated has a higher density value than the oil that has not been heated. This is not under the statement (Warsito *et al*., 2013), which states that the most significant oil density is the density of oil that has not been used or has not been heated. The oil still has molecules that have not been stretched due to heating and still have a large density. Cooking oil that has been heated has reduced molecular bonds and causes a decrease in density. The high-density value in this oil test is thought to be caused by the addition of antioxidant components that can affect the higher oil density value due to the antioxidant molecules or onion peel extract so that even though they have been heated, the molecules do not stretch, and the density value remains high. In addition, the high value of oil density can be caused by the remaining 80% ethanol solvent. This is supported by the statement Widyasanti *et al*. (2019), which states that the high-density value can be caused by a mixture of water so that the specific gravity value is close to the water density value, which is 1 g/ml.

Color Intensity

The analysis of variance showed that the addition of onion peel extract at various concentrations did not give a significant difference ($P>0.05$) to the color value of the oil. Based on the table, it was found that the oil with the addition of antioxidant BHT had a lighter color index of 32.50, while the oil with the addition of 3% onion peel extract had the darkest color among the five samples (Table 3).

Table 3. Color Intensity

Konsentrasi	**Color Intensity**				
	L	a	b	c	h
BHT	32.50 ± 0.30^{a}	-0.17 ± 0.55^{a}	32.50 ±1.27^{a}	1.03 ± 0.55^{a}	224.77 ± 91.87^{a}
0%	32.77 ± 0.41^{a}	-0.07 ± 0.32^{a}	32.77 ± 0.25^{a}	0.60 ± 0.36^{a}	193.83 ± 81.98^{a}
3%	33.17 ± 1.00^{a}	0.13 ± 0.40^{a}	33.17 ± 1.17^{a}	0.87 ± 0.91^{a}	142.30 ± 135.21^{a}
6%	33.13 ± 0.35^{a}	0.13 ± 0.25^{a}	33.13 ± 0.96^{a}	0.70 ± 0.70^{a}	206.73 ± 116.47^{a}
9%	32.93 ± 1.12^{a}	-0.13 ± 0.06^{a}	32.93 ± 0.15^{a}	0.63 ± 0.15^{a}	177.47 ± 141.32^{a}
12%	32.97 ± 0.85^{a}	0.43 ± 0.59^{a}	32.97 ± 0.32^{a}	1.10 ± 0.35^{a}	69.30 ± 30.60^{a}

Note: Data shown are the means ± standard deviation. Different superscript letters in the same column indicate a significant difference ($p<0.05$)

Oil with the addition of antioxidant BHT had a lighter color index of 32.50, while oil with 3% onion peel extract had the darkest color among the five samples (Table 3). The greater the concentration of onion peel used, the higher the intensity of the red color of the oil produced. This is due to the anthocyanin pigment from the onion peel, which also increases with increasing concentration. This is under the statement Lydia *et al*. (2011) red onion peel contains anthocyanin compounds which are thought to be the pigment that gives the peel a purplish red color. Table 3 shows that all treatments produce a yellowish color. The positive a* value evidence this. It still meets the standard of SNI No. 3741:2013 concerning cooking oil (2013) where cooking oil has a yellow to pale yellow color. According to Ketaren (1986) the red, orange, or yellow pigment is caused by oil-soluble carotenoids. Carotenoid compounds can be oxidized if heated at high temperatures, causing them to lose their function as antioxidants and vitamin A precursors (Gunstone and Padley, 1997).

The greater the concentration of onion peel added, the more concentrated the color will be. This is due to the higher anthocyanin pigments in the onion peel extract, causing an increase in the color density of the cooking oil. The analysis of variance showed that the addition of onion peel extract at various concentrations did not give a significant difference ($P>0.05$) to the h* value, namely the red, yellow, green, or blue color index values. Based on the table above, the results show that the oil with a concentration of 12% onion peel extract produces the lowest color index, which is 69.30, which indicates that the oil with the addition of 12% onion peel extract is included in the yellow green (YG) color criteria based on the hue range table. In comparison, the oil with the addition of 0.01% BHT concentration produces the highest color index, 224.77, which indicates that the oil with the addition of 0.01% BHT is included in the blue green (BG) color criteria based on the hue range table. This shows that the greater the concentration of onion peel added, the redder it will be. This is due to the higher anthocyanin pigments in the onion peel extract, causing an increase in the red color of the cooking oil. This is under the statement Virliantari *et al*. (2018) which states that anthocyanin compounds seen from their appearance cause red, red, purple, and blue colors.

CONCLUSIONS

These results demonstrated and verified that natural antioxidants from red onion peel extract have the ability as an antioxidant to ward off free radicals in palm oil. Furthermore, antioxidants from onion peel extract were able to maintain the stability of cooking oil compared to synthetic antioxidants BHT at a concentration of 9% based on the parameters of FFA, peroxide, total oxidation, P-anisidine, saponification number and iodine number.

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REFERENCES

Akhlus, -S., Herawati., 2006. Kinerja (Bht) sebagai antioksidan minyak sawit pada perlindungan terhadap oksidasi oksigen singlet. *Akta Kimindo*. *2*, 1–8. https://adoc.tips/download/kinerja-bht-sebagai-antioksidan-minyak-sawit-pada-perlindung.html

Anderson, D., Hossain, A., Shahidi, F. 2020. 'A Primer on Oils Processing Technology'. In Shahidi, F (ed.). *Bailey's Industrial Oil and Fat Products*. John Wiley & Sons. New York. https://doi.org/10.1002/047167849x.bio077.pub2

American Oil Chemist's Society (AOCS). 1997a. *AOCS Official Method Ca 5a-40. Official Methods and Recommended Practices of the AOCS (5th edn)*. Champaign

American Oil Chemist's Society (AOCS). 1997b. *AOCS Official Method Cd 3-25, Official Methods and Recommended Practices of the AOCS (A. O. C. S. Champaign (Ed.))*. Illinois

American Oil Chemist's Society (AOCS). 1997c. *Official Methods And Recommended Practices Of The AOCS*. Champaign

AOCS. (1997d). *Official Methods of Analysis. Cd 8-53, Cd 19-90*. Champaign

Ayucitra, -A., Indraswati, -N., Mulyandasari, -V., Kurniawan, -Y., Dengi, Y, -K., Fransisco, G., Yudha, -A., 2011. Potensi senyawa fenolik bahan alam sebagai antioksidan alami minyak goreng nabati. *Jurnal Widya Teknik*. 10, 1–10. https://doi.org/10.33508/wt.v10i1.155

Berry, D. 2003. *Food Product Design: Fat's Chance*. Week Publishing Company. Northbrook

Bimbo, A, -P., 1998. Guidelines for characterizing food-grade fish oil. *INFORM - International News on Fats, Oils and Related Materials*. 9(5), 473-483

BPS. 2020. Produksi tanaman sayuran. https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html

Bura Mohanarangan, A. 2012. Extraction of Omega-3 Fatty Acids from Atlantic Herring (*Clupea harengus*). Thesis. Dalhousie University. Canada

Deepika, -D., Vegneshwaran, V, -R., Julia, -P., Sukhinder, K, -C., Sheila, -T., Heather, -M., Wade, -M., 2014. Investigation on oil extraction methods and its influence on omega-3 content from cultured salmon. *Journal of Food Processing and Technology*. 5, 1–13. https://doi.org/10.4172/2157-7110.1000401

DKPI. 2018. Data komposisi pangan Indonesia. Accessed on 31 July 2018. <https://www.panganku.org/id-ID/view>

Eka, -B., Junianto., Rochima, -E., 2016. Pengaruh metode rendering terhadap karakteristik fisik, kimia dan organoleptik ekstrak kasar minyak ikan lele. *Jurnal Perikanan Kelautan*. 7, 1-5. http://jurnal.unpad.ac.id/jpk/article/view/13928/6667

Faridah, D, N., Lioe, H, N.,Palupi, N, S., Kahfi, J., 2013. Prediksi penurunan kualitas minyak goreng kelapa sawit menggunakan *Fourier Transform Infrared (FTIR) Spectroscopy* dengan analisis multivariat. *Proceeding Seminar Tahunan Maksi, IPB, Bogor,* pp. 204-218

Feryana, I, W, -K., Suseno, S, H., Nurjanah., 2014. Pemurnian Minyak ikan makerel hasil samping penepungan dengan netralisasi alkali. *Jurnal Pengolahan Hasil Perikanan Indonesia*. 17, 207–214. https://doi.org/10.17844/jphpi.v17i3.8907

Fieschi, -M., Codignola, -A., Mosca, A, M, -L., 1989. Mutagenic flavonol aglycones in infusions and in fresh and pickled vegetables. *Journal of Food Science*. 54, 1492-1495. https://doi.org/10.1111/j.1365-2621.1989.tb05143.x

Gordon, MH. 1990. 'The Mechanism of Antioxidant Action in Vitro'. In Hudson, BJF (ed.). *Food Antioxidants*. Springer. Netherlands. https://doi.org/10.1007/978-94-009-0753-9_1

Gunstone, FD, Padley, FB. 1997. *Lipid Technologies And Applications*. Ed. Marcel Decker. Inc, New York

Guo, -Q., Gao, -S., Sun, -Y., Gao, -Y., Wang, -X., Zhang, -Z., 2016. Antioxidant efficacy of rosemary ethanol extract in palm oil during frying and accelerated storage. *Industrial Crops and Products*, *94*, 82–88. https://doi.org/10.1016/j.indcrop.2016.08.032

Hamilton, R, -J., Kalu, -C., Mcneill, G, -P., Padley, F, -B., Pierce, J, -H., 1998. Effects of tocopherols, ascorbyl palmitate, and lecithin on autoxidation of fish oil. *Journal of the American Oil Chemists' Society*. *75*, 813–822. https://doi.org/10.1007/s11746-998-0231-4

Hermanto, -S., Muawanah, -A., Harahap, -R., 2008. Profil dan karakteristik lemak hewani (ayam, sapi, dan babi) hasil analisis FTIR dan GCMS. *Jurnal Kimia Valensi*. 1, 102-109. https://doi.org/10.15408/jkv.v1i3.219

Hutami, -R., Ayu, D, -F. 2015. Pembuatan dan karakterisasi metil ester dari minyak goreng kelapa sawit komersial. *Jurnal Agroindustri Halal*. 1(2), 124-131. https://doi.org/10.30997/jah.v1i2.371

International Union of Pure and Applied Chemistry (IUPAC). 1987. *Standard Methods for the Analysis of Oils Arld Fats and Derivatives*) *7th ed*. Blackwell Scientific. London

Khamdani, -S., Saptono, -M., Suparto, -H., Mahrita, -S., Syahrudin. 2011. Pengaruh waktu maserasi menggunakan pelarut heksana terhadap rendemen dan sifat kimia minyak kasar ampas biji kamandrah (*Croton tiglium L*). *Jurnal AGRIPEA*. 12(2), 1-5. https://jurnalagriepat.wordpress.com/2012/06/04/pengaruh-waktu-maserasi-menggunakan-pelarut-sholeh-khamdani-mofit-saptono-hairu-suparto-selvia-mahrita-dan-syahrudin/

Katrin., Bendra, -A., 2015. Aktivitas antioksidan ekstrak, fraksi dan golongan senyawakimia daun *Premna oblongata miq*. *Pharmaceutical Sciences and Research*. 2(1), 21-31. http://dx.doi.org/10.7454/psr.v2i1.3332

Ketaren, S. 1986. *Pengantar Teknologi Minyak dan Lemak Pangan*. Universitas Indonesia Press

Kochhar, SP, Rossell, JB. 1990. 'Detection, Estimation and Evaluation of Antioxidants in Food Systems'. In Hudson, BJF (ed.). *Food Antioxidants*. Springer. Netherlands. https://doi.org/10.1007/978-94-009-0753-9_2

Munsell, AEO. 1997. *Colour Chart for Plant Tissues. Mecbelt Division of Kalmorgen Instrument Corporation.* Baltimore. Maryland.

Lydia., Susanto, -T., Widjanarko, S, -B., 2001. Ekstraksi dan karakterisasi pigmen dari kulit buah rambutan (*Nepheliumla Ppaceumy*) ar. binjai. *Jurnal Teknologi Pangan dan Gizi*. 2, 1-16 https://doi.org/10.33508/jtpg.v2i1.137

Nurdianti, -L., Aryani, -R., Indra, -I., 2017. Formulasi dan karakterisasi SNE (Self Nanoemulsion) *Astaxanthin* dari *Haematococcus pluvialis* sebagai super antioksidan alami. *Jurnal Sains Farmasi & Klinis*. 4(1), 36-42. https://doi.org/10.29208/jsfk.2017.4.1.168

Panagan, A, -T., 2010. Pengaruh penambahan bubuk bawang merah (*Allium ascalonicum*) terhadap bilangan peroksida dan kadar asam lemak bebas minyak goreng curah. *Jurnal Penelitian Sains*. 6, 17-19. https://jpsmipaunsri.files.wordpress.com/2010/11/0517-19-c-almunadi-genap.pdf

Patty, -D., Papilaya, P, -M., Karuwal, R, -L., 2017. Penentuan kadar asam lemak bebas pada minyak jelantah dengan penambahan antioksidan alami kulit pisang raja (*Musa sapientum*). *BIOPENDIX: Jurnal Biologi, Pendidikan Dan Terapan*. 3, 124–128. https://doi.org/10.30598/biopendixvol3issue2page124-128

Purwaningsih, D, -Y., Zuchrilah, D, -R., Nurmala, I., 2019. Peningkatkan mutu minyak goreng curah dengan penambahan ekstrak kulit pisang raja sebagai antioksidan alami. *Reka Buana : Jurnal Ilmiah Teknik Sipil Dan Teknik Kimia*. 4, 22-29. https://doi.org/10.33366/rekabuana.v4i1.1058

Putri, D, -N., Wibowo, Y, M, -N., Santoso, E, -N., Romadhania, -P., 2020. Sifat fisikokimia dan profil asam lemak minyak ikan dari kepala kakap merah (*Lutjanus malabaricus*). *Agritech*. 40, 31–38. https://doi.org/10.22146/agritech.47039

Putri, D, -N., Manshur, H, -A., 2021. Physicochemical and fatty acid profile of fish oil from red snapper heads (*lutjanus malabaricus*) bleached from various bentonite concentrations. accessed on 6 July 2021. <https://eprints.umm.ac.id/83709/1/Putri%20Manshur%20-%20Red%20snapper%20heavy%20metal%20fish%20oil%20bleaching%20peroxide.pdf>

Quaresma, A, -V., Rubio, K, T, -S., Taylor, J, -G., Sousa, B, -A., Silva, S, -Q., Werle, A, -A., Afonso, R, J, C, -F., 2021. Removal of dexamethasone by oxidative process : structural characterization of degradation products and estimation of the toxicity. *Journal of Environmental Chemical Engineering*. 9(6), 1-13. https://doi.org/10.1016/j.jece.2021.106884

Rahayu, -S., Kurniasih, -N., Amalia, -V., 2015. Ekstraksi dan identifikasi senyawa flavonoid dari limbah kulit bawang merah sebagai antioksidan alami. *Al-Kimiya*. 2, 1–8. https://doi.org/10.15575/ak.v2i1.345

Rahim, A, M, E, -N., Prihatiningtyas, -I., 2017. Pengaruh katalis asam dan basa terhadap biodisel yang dihasilkan pada proses trans(esterifikasi) in situ biji karet (*Havea brasiliensis*). *Prosiding Seminar Nasional ReTII Ke-10*. 718-722. https://journal.itny.ac.id/index.php/ReTII/article/view/306

Rejeki, D, P., 2019. Ekstrak daun ubi jalar ungu sebagai antioksidan untuk memperlambat ketengikan (rancitditas) pada minyak kelapa. *Lantanida Journal*. 6, 103-202. https://doi.org/10.22373/lj.v6i2.3501

Rodrigues, A, -S., Pérez-Gregorio, M, -R., García-Falcón, M, -S., Simal-Gándara, -J., Almeida, D, P, -F., 2011. Effect of meteorological conditions on antioxidant flavonoids in Portuguese cultivars of white and red onions. *Food Chemistry*. 124. 303-308. https://doi.org/10.1016/j.foodchem.2010.06.037

Rohmawati, -S., Pangestuti, -D., Widjajanti, -L., 2017. Perbedaan jumlah bilangan peroksida minyak goreng dengan penambahan bawang merah dan bawang putih sebagai antioksidan alami (pada pedagang gorengan di wilayah kecamatan Tembalang kota Semarang tahun 2016). *Jurnal Kesehatan Masyarakat*. 5, 307-314. http://ejournal-s1.undip.ac.id/index.php/jkm

Roslan, N, -A., Abidin, S, -Z., Abdullah, -N., Osazuwa, O, -U., Rasid, R, -A., Yunus, N, -M., 2021. *Chemical Engineering Research and Design*. 1-11. https://doi.org/10.1016/j.cherd.2021.10.020

Rusdiana, R. 2015. Analisis Kualitas Minyak Goreng Berdasarkan Parameter Viskositas dan Indeks Bias. Skripsi. Universitas Islam Negri Walisongo. Semarang

Sallis, E. 2014. *Total Quality Management in Education*. Routledge. London

Seneviratne, K, Jayathilaka, N. 2016. *Coconut Oil: Chemistry and Nutrition*. Lakva Publishers. Sri Lanka

Shafizah, I, -N., Irmawati, -R., Omar, -H., Yahaya, -M., Aina, A, -A., 2022. Removal of free fatty acid (FFA) in crude palm oil (CPO) using potassium oxide/dolomite as an adsorbent: Optimization by Taguchi method. *Food Chemistry*. 373, https://doi.org/10.1016/j.foodchem.2021.131668

Shidiq, R, -A., Hidayati, -N., Mardiyono, M. 2018. Pengaruh ekstrak bawang merah (*Allium ascalonicum L*) terhadap bilangan peroksida pada penggunaan berulang minyak goreng kelapa sawit. *Biomedika*. 10, 47–51. https://doi.org/10.31001/biomedika.v10i2.274

Siswati, N, -D., Juni., Junaini., 2016. Pemanfaatan antioksidan alami flavonol untuk mencegah proses ketengikan minyak kelapa. *Jurnal Teknologi Pangan*. 4, 22-28. http://ejournal.upnjatim.ac.id/index.php/teknologi-pangan/article/view/433

Suseno, S, -H., Tajul, A, -Y., Wan Nadiah, W., 2011. The use of passive filtration for optimization of magnesol XL function for improving the quality of Sardinella lemuru oil. *Journal of Biochemistry and Bioinformatics*. 1, 103-113. https://repository.ipb.ac.id/bitstream/handle/123456789/77157/IRJBB_2011_Vol.1No.5_103-113.pdf.pdf?sequence=1&isAllowed=y

Standar Nasional Indonesia (SNI). 2006. Minyak Kelapa Sawit Mentah (Crude palm oil). SNI-01-2901: 2006. Badan Standardisasi Nasional, Jakarta

Soebagio, -B., Rusdiana, -T., Khairudin. 2007. Pembuatan gel dengan aqupec HV-505 dari ekstrak umbi bawang merah (*Allium cepa* , *L* .) sebagai antioksidan*. *Seminar Penelitian Dosen Fakultas Farmasi. Univesitas Padjadjaran. Bandung*. pp. 1-12

The Merck Index. The Merck Index 10th Ed. *Journal of Pharmaceutical Sciences*. https://doi.org/10.1002/jps.2600730651

Tompkins, -C., Perkins, E, -G. 1999. The evaluation of frying oilswith the *p*-anisidine value. *Journal of the American Oil Chemists' Society*. *76*(8), 945–947. http://lib3.dss.go.th/fulltext/Journal/J.AOCS/J.AOCS/1999/no.8/aug1999,vol76,no8,p945-947.pdf

Trilaksani, W. 2003. *Antioksidan: Jenis, Sumber, Mekanisme Kerja, dan Peran Terhadap Kesehatan*. Institut Pertanian Bogor. Bogor

Virliantari, D, A., Maharani, A., Lestari, U., Ismiyati., 2018. Pembuatan indikator alami asam-basa dari ekstrak kulit bawang merah (*Allium ascalonicum L.*). *Proceeding Seminar Nasional Sains dan Teknologi, Universitas Muhammadiyah Jakarta,* Jakarta, pp. 1-6

Wang, -S., Chu, -Z., Ren, -M., Jia, -R., Zhao, -C., Fei, -D., Su, -H., Fan, -X., Zhang, -X., Li, -Y., Wang, -Y., & Ding, -X., 2017. Identification of anthocyanin composition and functional analysis of an anthocyanin activator in solanum nigrum fruits. *Molecules*, *22*(6), 1–14. https://doi.org/10.3390/molecules22060876

Warsito., Pauzi, G, -A., Jannah, -M., 2013. Analisis pengaruh massa jenis terhadap kualitas minyak goreng kelapa sawit menggunakan alat ukur massa jenis dan akuisisinya pada komputer. *Proceeding Seminar Semirata FMIPA Universitas Lampung,* Lampung. pp. 35–41

Widayat., Suherman., Haryani, -K., 2006. Optimasi proses adsorbsi minyak goreng bekas dengan adsorbent zeolit alam : Studi pengurangan bilangan asam. *Jurnal Teknik Gelagar*. 17, 77–82. https://www.researchgate.net/publication/279669676_OPTIMASI_PROSES_ADSORBSI_MINYAK_GORENG_BEKAS_DENGAN_ADSORBENT_ZEOLIT_ALAM_STUDI_PENGURANGAN_BILANGAN_ASAM

Widyasanti, -A., Winaya, A, -T., Rosalinda, S. 2019. Pembuatan sabun cair berbahan baku minyak kelapa dengan berbagai variasi konsentrasi ekstrak the putih. *Agrointek*. 13, 132–142. http://dx.doi.org/10.21107/agrointek.v13i2.5102