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Red Palm Oil from Crude Palm Oil Refinement Using The Acid Degumming Method

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A B S T R A C T

Red Palm Oil (RPO) is the result of refining Crude Palm Oil (CPO). In further processing to obtain cooking oil, several processes are undergone to produce a clear oil, which is very different from its original product, CPO. RPO is rich in beta-carotene and its refining process does not include bleaching. The production of RPO utilizes the acid degumming method with different acid variations, namely phosphoric and sulfuric acid, with varying concentrations of 0.05% and 0.075%. The results showed that the average percentage of RPO produced reached 44.05%. Furthermore, the quality analysis of RPO also meets the SNI-3741-1995 standards (quality standard of cooking oil), with an average free fatty acid value of 1.41% (max 3%), a peroxide value of 1.04 mg oxygen/100 g (max 1.6 mg oxygen/100 g), and a moisture value of 0.04% (max 0.3%).

INTRODUCTION

Red Palm Oil (RPO) is a refined product derived from Crude Palm Oil (CPO). CPO itself is oil obtained from the mesocarp or fibrous husk of the oil palm fruit (*Elaeis guineensis Jacq*). The total carotene content in RPO is 550 µg/g. With this content, one teaspoon of RPO, or about 5 grams, provides 270.77 RE (135.38 RAE) of vitamin A, which is 54.15% of the Recommended Dietary Allowance and 67.69% of the Dietary Reference Intakes (IOM 2004) for children aged 4 - 8 years (Hasibuan & Ijah, 2018; Sumarna, 2007; Widhiastuti, 2011).

CPO is characterized by its reddish-yellow color, indicating a high carotenoid content. Palm oil has superior nutritional content compared to olive oil, soybean oil, and corn oil. In addition to containing provitamin A, such as α-carotene and β-carotene, and vitamin E (tocopherol and tocotrienol), palm oil contains various other bioactive compounds like riboflavin, niacin, lycopene, and minerals including phosphorus, potassium, calcium, and magnesium (Tan et al., 2021).

To produce palm oil with a high carotenoid content, the bleaching and deodorization processes are omitted. This is because minor components like carotenoids would be absorbed by bleaching earth and degraded by the high temperatures (260 – 280°C) and low vacuum pressure during deodorization. Bleaching earth can absorb about 20 to 50% of the carotenoids in degummed oil. The product resulting from this process is called RPO. RPO is palm oil that is obtained without the bleaching process with the aim of retaining its carotenoid content (Rakprasoot, Tiampakdee, et al., 2023; Tan et al., 2021).

The objective of this research is to obtain RPO from the refining process of CPO using the acid degumming method. The resulting RPO is expected to have good quality, be suitable for consumption, and meet the SNI standards for cooking oil.

LITERATURE REVIEW

Beta carotene

Red palm oil contains carotene levels ranging from 600 to 1000 ppm. The carotenoids present in palm oil consist of approximately 36.2% α-carotene, 54.4% β-carotene, 3.3% τ-carotene, 3.8% lycopene, and 2.2% xanthophyll. Palm oil contains about 800 ppm of tocopherol, which is a mixture of 20% α-tocopherol, 25% α-tocotrienol, 45% τ-tocotrienol, and 10% δ-tocotrienol. This group of tocopherol compounds acts as natural antioxidants and is also physiologically active as a vitamin, specifically vitamin E. 600 types of carotenoids have been isolated in nature. Among the carotenoids contained in red palm oil, 91.18% are β-carotene and α-carotene, which have high provitamin A activity. The carotene content in red palm oil is 60 times greater than that in cooking oil. Carotenoids impart an orange-to-red color to palm oil. Specifically, α-carotene and β-carotene are precursors to vitamin A in the body. Provitamin A is equivalent to 2 units of vitamin A and has 100% vitamin A activity. Red-colored palm oil can be used to combat vitamin A deficiency due to its β-carotene content. Additionally, it can be used to prevent coronary heart disease and cancer, as well as to replace damaged cells (Purnama et al., 2020; Rakprasoot, Tiampakdee, et al., 2023; Tan et al., 2021).

Purification process of CPO

The processing of cooking oil in a plant generally consists of refining and fractionation. The refining process includes degumming, neutralization, bleaching, and deodorization. The oil obtained from refining consists of olein (cooking oil) and stearin, which are separated during the fractionation process. To produce Red Palm Oil, the bleaching and deodorization processes are not conducted in order to preserve the carotenoid content.

1. Degumming

Degumming is the process of separating gum or mucilage, which consists of phosphatides, proteins, residues, carbohydrates, water, and resin. Several methods can be used for gum separation, including heating, the addition of acids (H_3PO_4, H_2SO_4, and HCl), separation with NaOH, dehydration, and separation using specific reagents such as phosphoric acid, NaCl, and Na_3PO_4 (Elvira Kusuma et al., 2023; Sumarna, 2007).

2. Neutralisation

Neutralization is a process to separate free fatty acids from oil or fat by reacting free fatty acids with a base or other reagents to form soap stock. Neutralization with NaOH is widely used in the industrial scale because it is more efficient and cheaper compared to other neutralization methods based on the principle of saponification reaction between free fatty acids and a solution of caustic soda, with the saponification reaction as follows:

$$R\text{--}COOH + NaOH \rightarrow R\text{-}COONa + H_2O$$

The optimum reaction conditions at atmospheric pressure occur at a temperature of 70°C, where the reaction is an equilibrium reaction that will shift to the right. Typically, an excess of caustic soda is used, about 5% more than the stoichiometric requirement. The formed soap is separated by precipitation (Afrizal et al., 2022; Hasibuan & Ijah, 2018).

3. Fractionation

The fractionation process consists of crystallizing a fraction to become solid at a certain temperature, followed by the separation of the two fractions. The fraction that crystallizes is stearin, while the remaining liquid is olein. Some commonly used fractionation processes include:

a) Dry fractionation (fractionation without a solvent)
b) Wet fractionation (fractionation with a solvent)
c) Fractionation using a solution of sodium lauryl sulfate detergent

Dry fractionation is based on cooling the oil under controlled conditions without adding any chemicals. There are three operations involved: seeding, crystallization, and filtration. Initially, the oil is heated to 70°C to obtain a homogeneous liquid and then cooled with cooling water to a temperature of 40°C, then further cooled to 20°C and maintained until the crystallization

process is complete (Gibon, 2012; Huey et al., 2016; Kuriyama et al., 2011; Nusantoro, 2007; Saputra, Rantawi, et al., 2023).

The parameters that can be used to determine the quality of the produced oil can be seen from the levels of Free Fatty Acid (FFA), Peroxide Value, and Moisture Content. For comparison, the quality of cooking oil according to SNI-3741-1995 is as follows:

Table 1. Quality Standards for Cooking Oil Based on SNI 3741-1995

No	Criteria	Persyaratan
1	Odor and Taste	Normal
2	Color	Light Clear
3	Moisture Content	Max *0,3%*
4	Specific Gravity	0.900 kg/liter
5	Free Fatty Acids	Max *3%*
6	Peroxide Value	Max 1.6 mg Oxygen/100g
7	Iodine Value	45-46
8	Saponification Value	196-206
9	Refractive Index	1.448-1.450
10	Heavy Metal Contaminants	Max 0.1 mg/kg

METHODOLOGY

Tools and materials

The tools used in conducting this research includes a hot plate, volumetric flask, erlenmeyer flask, funnel, spectrophotometer, beaker glass, filter paper, dropper pipette, spatula, oven, thermometer, container, magnetic stirrer, centrifuge tube, analytical balance, burette, petri dish, pH paper, measuring glass, pycnometer, stirring rod, and stopwatch. The materials used in conducting this research include CPO samples, phosphoric acid (H_3PO_4), sulfuric acid (H_2SO_4), distilled water (aquadest), n-hexane, NaOH, ethanol, 2-propanol, HCl, phenolphthalein indicator, saturated KI solution, sodium thiosulfate, potassium dichromate, acetic acid: chloroform, and 1% starch indicator.

Purification of CPO into RPO

1. Degumming Process

   The CPO samples, each weighing 200 g, were heated on a hot plate magnetic stirrer at a temperature of 40°C and stirred with a magnetic bar until homogeneous. Phosphoric acid was added at a concentration of 0.05% to samples (1 and 2), and at a concentration of 0.075% was added to samples (3 and 4). Sulfuric acid was added at a concentration of 0.05% to samples (5 and 6), and at a concentration of 0.075% was added to samples (7 and 8). The mixture of CPO and acid solution was heated on a hot plate magnetic stirrer at a temperature of 80°C for 2 hours and stirred at a speed of 500 rpm. After 2 hours, distilled water was added to the mixture of CPO and acid solution at a concentration of 5%. Then, the

CPO was heated again on a hot plate magnetic stirrer at a temperature of 60°C for 15 minutes. The solution was centrifuged at a speed of 6000 rpm for 15 minutes to separate the gum and CPO. The CPO and tube centrifuge were poured into a beaker, taking care not to carry the gum. The degummed CPO had a brighter color compared to the original CPO. The mass of CPO after degumming was calculated.

2. Neutralisation Process
   The degummed CPO was treated with a 0.1 N NaOH solution at a concentration of 0.1% of the mass of CPO after degumming. The CPO sample was stirred for 25 minutes at a speed of 56 rpm, maintaining a temperature of 90°C. The sample was then centrifuged at a speed of 3000 rpm to separate the oil from the free fatty acids. The centrifuged product was poured into a glass beaker, and the result of the neutralization process was weighed.

3. Fractination Process
   The neutralized oil was cooled to 20°C and left to stand for 24 hours in a water bath to separate the olein and stearin. After the sample was separated into olein and stearin, it was filtered using filter paper. The olein obtained is Red Palm Oil (RPO), then its mass was measured. Red Palm Oil (RPO) was tested for Free Fatty Acids (FFA), Peroxide Value (PV), and moisture content after the refining process (Saputra, Siregar, et al., 2023; Simatupang et al., 2020, 2022; Tarigan & Simatupang, 2019).

RESEARCH RESULT

Figure 1. Red Palm Oil

Table 1. Data Tabulation of Research Results

Sample No	Initial Mass (g)	Processes						Result (%)
		Degumming (g)	Result (%)	Netralisation (g)	Result (%)	Fraksination (g)	Result (%)	
1	197,9	196,08	0,92	161	17,89	127,39	20,88	35,63
2	198,2	164,72	16,89	116,67	29,17	98,17	15,86	50,47
3	200,53	188,13	6,18	129,89	30,96	85,28	34,34	57,47
4	200,08	151,06	24,50	125,92	16,64	102,55	18,56	48,75

5	199,23	179,77	9,77	140,75	21,71	132,95	5,54	33,27
6	199,23	172,04	13,65	121,29	29,50	116,48	3,97	41,53
7	195,4	155,84	20,25	101,06	35,15	96,29	4,72	50,72
8	199,76	172,14	13,83	138,68	19,44	130,72	5,74	34,56
Average	198,79	172,47	13,25	129,41	25,06	111,23	13,70	44,05

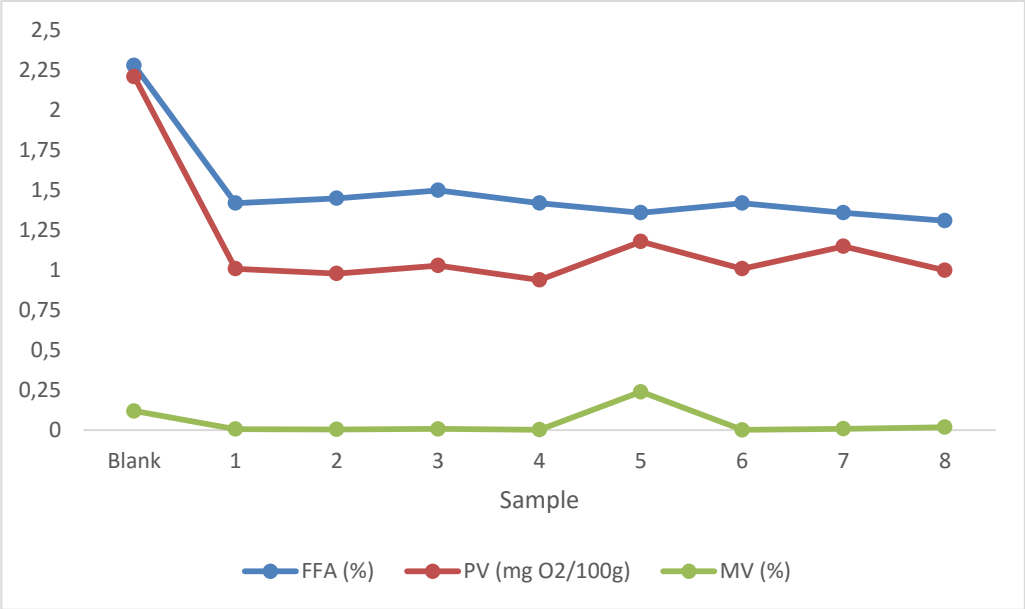

Figure 2. FFA, Peroxide Value (PV) and Moisture Value (MV) on RPO

DISCUSSION

The processing method of Red Palm Oil essentially aims to preserve the naturally occurring carotenoid content in Crude Palm Oil (CPO). Therefore, bleaching and deodorization are not performed in the refining process. In the refining process, specifically the degumming stage, the researcher utilizes the acid degumming method. This method serves as the initial stage in the purification process. Degumming involves the separation of gum or mucilage, which consists of phosphatides, proteins, residues, carbohydrates, water, and resins. The acids used in this process are phosphoric acid (H_3PO_4) and sulfuric acid (H_2SO_4). Different concentrations of acid addition are employed, namely: 0.05% and 0.075% for the acid degumming process, which facilitates the separation of gum and mucilage with acid addition. This process employs a centrifuge. Subsequently, neutralization with 0.1 N NaOH is carried out to separate free fatty acids from oil and fat. The final stage is fractionation, which involves separating olein from stearin using a waterbath (maintained at 20°C). In Figure 1, the red-colored RPO obtained from the purification process can be observed.

Table 1 showed the percentage reduction in sample mass from the beginning to the end of the process based on the addition of acid during the degumming stage. The acids used in degumming are phosphoric acid with concentrations of 0.05% (samples 1 and 2) and 0.075% (samples 3 and 4), and sulfuric acid with concentrations of 0.05% (samples 5 and 6) and 0.075%

(samples 7 and 8). The percentage reduction in sample mass from the beginning of the process to the end of the purification process resulting in Red Palm Oil is shown, with the highest reduction percentage found in sample 3 at 57.47%.

Figure 2 presented the free fatty acid values. The Red Palm Oil processed using three stages—Degumming, Neutralization, and Fractionation—showed a lower free fatty acid content than the blank sample/CPO. This is due to the three purification stages performed, particularly during the neutralization process, which caused a significant reduction in free fatty acids in the sample. The neutralization process separates the oil from the free fatty acids by reacting them with a base or other reagents. The free fatty acid (FFA) content in the resulting Red Palm Oil (RPO) still meets the SNI standard, which is a maximum of 3%.

The peroxide value indicates the degree of oxidation in the oil or fat. Unsaturated fatty acids can bind oxygen at their double bonds to form peroxides, which subsequently form aldehydes. This process causes unpleasant odors and flavors, leading to rancidity in the oil. A higher peroxide value means there are more peroxides present in the sample. For the Red Palm Oil produced, only a small amount of sodium thiosulfate solution is required to titrate the formed I2. The smaller the peroxide value obtained, the less damage has occurred in the oil. The test results show that the smallest peroxide value is found in sample 8, with a value of 1.31 mg Oxygen/100 g. All RPO samples produced meet the SNI standard, which is a maximum of 1.6 mg Oxygen/100 g.

The moisture content is the amount of water contained in the oil, which determines the oil's quality. The lower the moisture content, the better the quality of the oil. This is because the presence of water in the oil can trigger hydrolysis reactions that lead to a decrease in oil quality. The test results show that the lowest moisture content is found in sample 4, with a value of 0.003%. However, as seen in the graph above, sample 5 shows a significantly higher moisture content of 0.24% compared to the other samples. This is because the fractionation process, which involves separating olein and stearin in sample 5, took longer than in the other samples due to unstable temperatures. Nevertheless, the moisture content test results for all Red Palm Oil samples still meet the SNI standard, which is a maximum of 0.3%.

CONCLUSIONS AND RECOMMENDATIONS

The Red Palm Oil produced using the methods of acid degumming, neutralization, and fractionation meets the SNI standards. The percentage reduction in sample mass from the beginning to the end of the process for the resulting RPO ranges between 33.27% and 57.47%. The characteristics of the Red Palm Oil with the highest quality were found in sample 4, which used phosphoric acid at a concentration of 0.075%, yielding an FFA of 0.94%, a peroxide value of 1.42 mg Oxygen/100 g, and a moisture content of 0.003%.

ADVANCED RESEARCH

Further research is needed with different variations of acid addition in the production of Red Palm Oil and to check the β-Carotene levels in the raw material and the resulting RPO.

REFERENCES

Afrizal, Y., Dewi, E., Mustain, D., Teknik, J., Program, K., Teknologi, S., Industri, K., Sriwijaya, N., Srijaya, J., Bukit, N., & Palembang, B. (2022). Pengolahan crude palm oil (cpo) menjadi minyak sawit merah (msm) menggunakan filter batuan zeolit, membran keramik dan cartridge filter. *Jurnal Kinetika*, *13*(03), 11–19. https://jurnal.polsri.ac.id/index.php/kimia/index

Elvira Kusuma, D., Mardawati, E., & Nurhasanah, S. (2023). Evaluasi Perubahan Warna dalam Tahapan Pengolahan Minyak Mentah Sawit menjadi Minyak Sawit Merah dan Minyak Goreng Sawit sebagai Indikator Kandungan β-Karoten Minyak Color Changes. *Biomass, Biorefinery and Bioeconomic*, *1*(1), 25–29.

Gibon, V. (2012). Palm Oil and Palm Kernel Oil Refining and Fractionation Technology. In *Palm Oil: Production, Processing, Characterization, and Uses* (pp. 329–375). Elsevier Inc. https://doi.org/10.1016/B978-0-9818936-9-3.50015-0

Hasibuan, H. A., & Ijah. (2018). Peningkatan kesukaan minyak sawit merah dengan penambahan minyak nabati atau flavor dan stabilitasnya dalam penggorengan berulang. *Jurnal Penelitian Kelapa Sawit*, *26*(1), 1–9.

Huey, S. M., Let, C. C., & Beng, C. (2016). *Palm Oil Developments 62 New Developments in Palm Oil Fractionation*.

Kuriyama, J., Miyaji, ;, Tamura, ;, Zaliha, ;, & Chong. (2011). Improved sustainable fractionation of palm oil using polyglycerol fatty acid esters. *Journal of Oil Palm Research*, *23*, 1141–1145.

Nusantoro, B. P. (2007). Dry fractionation of rbd (refined bleached and deodorized) palm oil. *AGRITECH*, *27*(4), 171–175.

Purnama, K. O., Setyaningsih, D., Hambali, E., & Taniwiryono, D. (2020). Processing, Characteristics, and Potential Application of Red Palm Oil - A review. *International Journal of Oil Palm*, *3*(2), 40–55. https://doi.org/10.35876/ijop.v3i2.47

Saputra, H., Rantawi, A. B., & Simatupang, D. F. (2023). Fabrikasi Sabun Transparan Berbasis Minyak Olein dan Ekstrak Serai. *JUSTEK: Jurnal Sains Dan Teknologi*, *6*(2), 207–213. https://doi.org/10.31764/justek.v6i2.15112

Saputra, H., Siregar, A. L., Oktavia, R. Y., & Simatupang, D. F. (2023). Sintesis Biooil dari Limbah Pelepah Kelapa Sawit Berbasis Metode Pirolisis. *REACTOR: Journal of Research on Chemistry and Engineering*, *4*(1), 12–18. https://doi.org/10.52759/reactor.v4i1.68

Simatupang, D. F., Agfira, U. N., Angela, A., Simbolon, M., Teknologi, P., Industri, K., Teknologi, P., Industri, K., Merauke, U. M., & Education, P. (2022). Determination of Content and Oil Losses in Meal through Palm Kernel Pressing Process at PT XYZ Belawan. *CHEESA: Chemical Engineering Research Articles*, *5*(2), 65–73. https://doi.org/10.25273/cheesa.v5i2.9255.65-73

Simatupang, D. F., Tarigan, J., & Mansyur. (2020). The effect of active carbon adsorbents from some wastes in reducing free fatty acids and acid number to improve vco quality. *IOP Conference Series: Materials Science and Engineering*, *885*(1), 6–11. https://doi.org/10.1088/1757-899X/885/1/012011

Sumarna, D. (2007). Keuntungan proses wet degumming dibanding dry degumming pada pemurnian minyak sawit kasar. *Jurnal Teknologi Pertanian*, *3*(1), 37–42. https://www.researchgate.net/publication/348555753

Tan, C. H., Lee, C. J., Tan, S. N., Poon, D. T. S., Chong, C. Y. E., & Pui, L. P. (2021). Red palm oil: A review on processing, health benefits and its application in food. In *Journal of Oleo Science* (Vol. 70, Issue 9, pp. 1201–1210). Japan Oil Chemists Society. https://doi.org/10.5650/jos.ess21108

Tarigan, J., & Simatupang, D. F. (2019). Uji Kualitas Minyak Goreng Bekas Pakai Dengan Penentuan Bilangan Asam, Bilangan Peroksida Dan Kadar Air. *Ready Star* , *2*(1), 6–10.

Rakprasoot, J., Tiampakdee, A., & Raviyan, P. (2023). Processing of red palm oil by modified acid degumming method. *Food Agricultural Sciences and Technology*, *9*(2), 11–22.

Widhiastuti, Y. (2011). *Pemanfaatan Red Palm Oil (RPO) Sebagai Provitamin A Pada Produk Sosis Keong Tutut (Bellamnya Javanica Van Den Bush)*. IPB.