

Engineering Process Of Deodorization To Improve Product Quality Of Red Palm Oil With Rich Of Carotene

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Abstract— Efforts to develop the production technology of high quality red palm-oil (RPO) in order to provide source of food ingredient that naturally rich of nutrients, become urgents regarding the need of such products drastically increased recently. Application of deodorization technology by temperature, time, and deodorizer pressure combinations (engineering of deodorization process) are studied and evaluated to obtain good quality of RPO. Crude palm oil (CPO) used in this research were supplied by PT. Salim Ivomas (Bimoli) Jakarta. The equipments used were degumming and neutralization unit, deodorization unit and other equipment units to analyze the oil physico-chemical properties. The research consisted of 5 stages as the following: characterising CPO physico-chemical properties, conducting chemically degumming and deacidification, process engineering of deodorization, characterizing of physico-chemical properties and organoleptic of RPO resulted, and analyzing data for product resulted from process engineering applied. Deodorization with the range of temperature and process duration of 135–145 °C (408–418 K) and 1–4 hours have led to carotene retention decreasing (%) following the equation “Carotene Retention (%) = $-764 \times \ln(\text{absolute temperature}) + 4693$ ” and process duration with the equation “Carotene Retention (%) = $-7.81 \times \ln(\text{process duration}) + 91.02$ ”; and also resulted odor intensity with the equation “Odor Intensity = $0.08 \times (\text{squared absolute temperature}) - 66.88 \times (\text{absolute temperature}) + 13823$ ” and duration process with the equation “Odor Intensity = $0.315 \times (\text{squared process duration}) - 1.52 \times (\text{process duration}) + 5.268$ ”. Effective deodorization to produce RPO with the content of free fatty acid and peroxide value that met the requirements of Indonesian National Standard (SNI) quality of carotene content above 400 ppm and odor scale below 3.3, were the combination of temperature (T) of 141.34 °C, heat process duration (t) of 2.35 hours and vacuum pressure of (P) of 20 mmHg. The resulted RPO contained free fatty acid and peroxide value of 0.11% dan 0.12 meq/kg oil respectively, total carotene of 444.09 ppm and odor value of 3.21

Keywords: Carotene, deodorization, food ingredient, pro-vitamin A, Red Palm Oil

I. INTRODUCTION

Due to the potency of Indonesia as the largest producer of palm oil in the world and as the increasing demand of natural food ingredient with rich nutrient, red palm oil (RPO) has best potency for commercialization. Therefore, the research to find production technology of red palm oil with the best quality is urgently needed.

Previous research has produced RPO with the free fatty acid content and peroxide value that met the requirements of Indonesian National Standard (SNI) frying oil, but with the carotene content < 400 ppm and the odor quality is relatively low. For that reason, application of deodorization technology with the combination of temperature, time, and deodorizer pressure (deodorization process engineering), which the treatments in this research, were being examined and evaluated to obtain the RPO products with the appropriate quality as the ingredients/fortificants of Pro Vitamin A in food industry products.

II. MATERIAL AND METHODS

The main material used in this research was crude palm oil (CPO) supplied by PT. Salim Invomas (Bimoli) Jakarta. Instruments used were deodorization unit and other instruments needed to conduct the physico-chemical analyses of oil. Deodorization was conducted with batch system using 100 kg deodorizer scale by heating Neutralized Red Palm Oil (NRPO) in vacuum condition till the designed/set temperature. The flow rate of trigger gas (N₂) was maintained at 20 L/hour during deodorization process. Variables of process being observed for the effect on RPO product quality were vacuum pressure, temperature and the time length of deodorization process. The treatment was designed as complete random with two replications.

Deodorization process conditions involved the arrangement of temperature, flow of trigger gas, and vacuum pressure. Heating was set at 140 °C for 2 hours, referred to the experiment of Mayamol *et al.* (2007) to produce RPO with the high retention of carotene. Trial process was conducted by entering oil bait in batch and the description of treatment code for each batch are presented in Table 1 that has been adjusted to the equipment limitation. After the bait entered, homogenization was conducted at temperature of 46±2°C for 10 minutes and then samples were taken for physico-chemical analysis of NRPO. Working pressure of deodorizer could reach 5 mmHg, soon after baits, pressure drastically decreased and took some time to reach

pressure of 20-30 mmHg. After the operational temperature and pressure being reached, the record of temperature, pressure and duration of deodorization process were begun.

Table 1. Treatment code in each combination of temperature, pressure and duration of deodorization process

Treatment Code	Temperature, pressure and duration of deodorization
Batch 1	T=138,68 °C; t=2,31 jam; P=25 mmHg
Batch 2	T=138,68 °C; t=1,31 jam; P=25 mmHg
Batch 3	T=142,57 °C; t=3,76 jam; P=20 mmHg
Batch 4	T=142,57 °C; t=2,76 jam; P=20 mmHg
Batch 5	T=142,05 °C; t=2,36 jam; P=25 mmHg
Batch 6	T=142,05 °C; t=1,36 jam; P=25 mmHg
Batch 7	T=141,34 °C; t=2,35 jam; P=20 mmHg
Batch 8	T=141,34 °C; t=1,36 jam; P=20 mmHg

After deodorization time was reached, the flow of N₂ was closed, and temperature was decreased by flowing cold water gradually, followed by turning off vacuum pump. Afterward, oil was circulated by product pump till temperature below 50 °C and 500 ml sample was taken for NDRPO physico-chemical analysis.

Red oil (NDRPO) obtained from trial deodorization being analyzed its physico-chemical properties for water content (SNI 01-2901-2006), free fatty acid (AOCS Ca 5a-40 1993), peroxide value (AOCS Cd 8-53 2005), carotene retention (PORIM 2005), and odors intensity (organoleptic analysis by using method of Meilgaard *et al.* 1999). Several parameters of resulted physico-chemical analysis before and after deodorization process and then being transformed in percentage form of water content reduction, carotene retention, Free Fatty Acids (FFAs) changes, and Peroxides value (PV) reduction as the performance measures of deodorization, meanwhile odor parameter was declared as overall odor intensity level.

The odor intensity of red palm oil is determined by organoleptic differentiation test using rating method of typical odor of palm oil. odor intensity is described as an unstructured scaling scale of 0-10. A score of 10 is given for the sample of red palm oil before deodorizing and a score of 0 is given for the commercial palm oil. The organoleptic test was conducted with specially trained panelist (Meilgaard *et al.* 1999).

III. RESULT AND DISCUSSION

1. Odor Intensity

In this research, odor from oil sample was measured in scale of 0 – 10, value 10 is the highest odor intensity represented by CPO with impure condition and value 0 is the lowest intensity represented by commercial frying oil (olein fraction from twice RBDPO fractionation). In organoleptically odor test, panelists were trained to recognize and to rate odor intensity. Analysis of variance indicated the results were not significantly different among treatments ($P < 0.05$). Graph observation showed that temperature increasing was able to reduce odor intensity (score become lower). The same as contact period, the longer time of deodorization process will reduce the intensity of oil odor. Deodorization process at temperature of 141.05°C for 2.35 hours and pressure of 20 mmHg was able to give low score (3.210). The lower the score of NDRPO, the higher the quality, which means that the NDRPO odor are similar to commercial frying oil odor. RPO odor intensity in each treatment of temperature, process duration and vacuum pressure applied is presented in Figure 1.

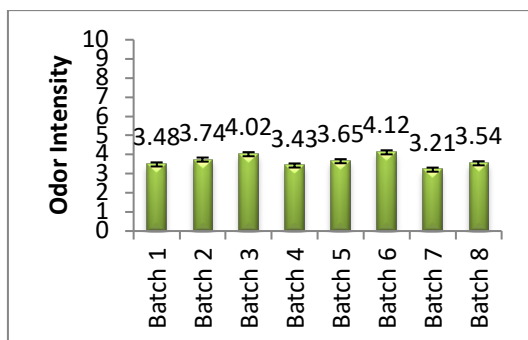


Figure 1. Organoleptic analysis result of RPO odor intensity in each treatment of temperature, process duration and vacuum pressure. Details of each batch are listed in Table 1.

2. Retention and Carotene content of NDRPO

Carotene in oil palm is one of nutritive component which easily degraded by heating and oxidation process. Deodorization in purification of this red palm oil has involved high temperature that can lead to the decrease of carotene content in red palm oil. Therefore, the level of degraded carotene due to deodorization process can be calculated in percentage of carotene retention. The higher the retention of carotene, the lower the carotene degraded.

Carotene retention was calculated based on the ratio of remain carotene content and initial carotene content prior to deodorization. Caroten content and retention of deodorization product (NDRPO) are presented in Table 2.

The highest carotene retention (91.27%) was resulted from deodorization process at temperature of 138.68°C for 1.31 hours with the pressure of 25 mm Hg, meanwhile, the lowest value (80,52%) was appeared in deodorization process at 142.57 °C for 3.76 hours with the pressure of 20 mmHg. The rate of carotene degradation was higher at high temperature and long time period of deodorization. The increase of temperature has reduced retention of carotene. It also happened to deodorization period, the longer the deodorization period the lower the carotene retention.

Vacuum difference could affect the differences of carotene retention. The high vacuum level assures oxygen availability of oil can be reduced as maximum as possible. The existence of dissolved oxygen has triggered the reaction of carotene decomposition. According to Sundram (2007), beside of carotene light sensitivity to oxygen, carotene oxidation is triggered by hydroperoxide produced by lipid oxidation, caused discolorization and bleaching. Oxidation reaction can cause the carotene color disappearance of food (Scwartz dan Elbe 1996). Oxidation can be randomly occurred at double bound-carbon chain (Bonnie dan Choo 1999). Effect of temperature on carotenoid oxidation reported by Worker (1957) in Muchtadi (1992) proved that carotenoid was not degraded due to heating at 60°C, whereas Gross (1991) stated that rate of β -carotene oxidation increased as well as temperature.

Table 2. Parameter of treatments and characteristics of deodorization products (RPO) resulted

Treatment/characteristics	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8	NRPO
Temperature (°C)	138.68	138.68	142.57	142.57	142.05	142.05	141.34	141.34	-
Pressure (mmHg)	25.00	25.00	20.00	20.00	25.00	25.00	20.00	20.00	-
Process period (hour)	2.31	1.31	4.16	3.16	2.36	1.36	2.35	1.35	-
Flow N2 (L/hour)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	-
FFA content (%)	0.08	0.11	0.11	0.12	0.13	0.12	0.12	0.12	0.14
PV (meq/kg)	0.10	0.10	0.10	0.19	0.10	0.10	0.14	0.16	0.45
Carotene content (ppm)	459.03	477.15	437.08	459.90	428.87	425.48	444.09	448.21	524.09
Water content (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
Decreasing of FFA (%)	50.13	29.32	15.02	8.68	8.43	9.81	4.91	6.02	-
Decreasing of PV (%)	83.85	83.84	78.11	53.30	78.90	71.51	55.97	51.89	-
Decreasing of Carotene (%)	12.19	8.73	16.89	12.14	18.88	19.48	14.66	13.87	-
Decreasing of water content (%)	98.89	96.78	99.01	99.14	98.80	98.96	99.11	98.89	-
Carotene retention	87.81	91.27	83.11	87.86	81.12	80.52	85.34	86.13	-
Odor intensity	3.48	3.74	4.02	3.43	3.65	4.12	3.21	3.54	-

Remarks: Details of treatment combination for each batch is presented in Table 1.

Yusoff *et al.* (1996) also found different effect of deodorization temperature on carotene retention in oil palm olein. There is a significant decrease of carotene during deodorization at 170°C. Previous research also showed the effect of carotene on temperature, namely: Alyas *et al.* (2006) in his research about red palm olein (RPOn) oil heating has observed that there was a decrease about 59% at heating temperature of 200°C.

Rianto (1995) reported that there was significant interaction between heating temperature and period to the decrease of carotene total. It means that, the higher temperature of heating, the higher the decrease of total carotene with the same heating period/duration, and also the longer the heating the higher the decrease of total carotene at the same heating temperature. The decrease of total carotene would increase when the heating done in high temperature with the longer heating period.

3. Water content, Free Fatty Acid and Peroxide Value

Water content is one the quality requirements of oil palm resulted from purification. High water content can trigger oil degradation through hydrolysis so that it will increase free fatty acid content (Scrimgeour 2005). NDRPO resulted in deodorization process has zero water content, that is below the maximum water content required for NDRPO (*Neutralized Deodorized Red Palm Oil*). Data of water content decrease during deodorization process is presented in Table 2.

Decrease of water content was due to water molecules being vapoured when deodorization process took place in vacuum condition. Theoretically, vacuum pressure lead to an increase of vapour pressure from water molecules, so that water is easy to vapour at temperature below atmospheric melting point. Combination of high temperature and low pressure (sub atmospheric) helps evaporation of water molecules, whereas then being stripped mainly through absorption into nitrogen gas bulbs (Tsiadi *et al.* 2001). Data presented in Table 2 showed the water content decrease of deodorization product (NDRPO) for each treatment of temperature, process period and vacuum pressure. The highest decrease of water content was 99,14% at temperature of 142,57°C for 2,76 hours with the pressure of 20 mmHg.

Free fatty acid (FFA) content of oil is an acid number measured by molecule weight of fatty acid or mixture of it. Value of FFA content is an indicator of oil quality and also as achievement parameter from process phases. Free fatty acid content of NDRPO in this research is listed in Table 2.

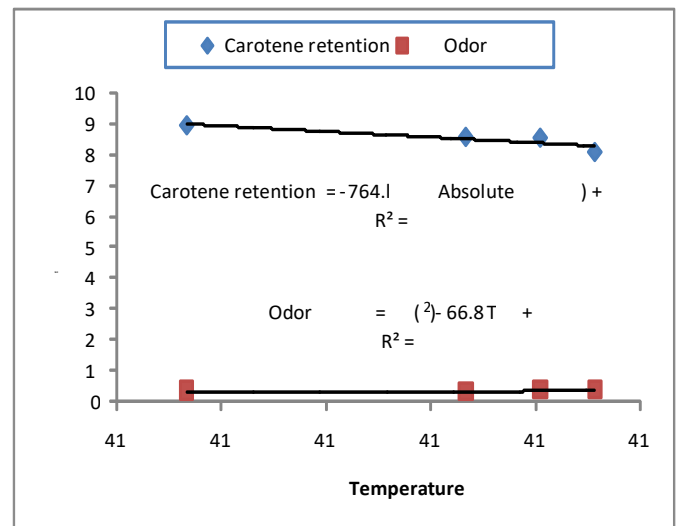
Differences of free fatty acid content after being deodorized showed that treatment of temperature, period, and deodorization vacuum pressure affected FFA changes. Effect of deodorization on FFA oil composition is different for each kind of oil with the different fatty acid composition. FFA composition in oil are mainly affected by its FFA composer. Primary fatty acids composing oil palm are palmitic acid and oleic acid. Figure 5 showed that the highest decrease of FFA occurred at temperature of 138.68 °C for 2.31 hours with the pressure of 25 mmHg.

Peroxide value is one of parameters to determine oil degradation level. RPO peroxide value was measured to assess whether deodorization process could make oil palm being oxidized or not. The decrease of peroxide values after deodorization occurred were very intensive, RPO peroxide values at the end of process was very low (< 1 meq O₂/kg), far below maximum limit required by SNI (below 5 meq O₂/kg) (Table 2).

PV differences between red oil before and after deodorization were quite significant. The highest PV decreases happened at 138.68°C for 2,31 hours with pressure of 25 mmHg. At 138.68 °C, decreases of PV reached 83,85%. The lowest PV decrease at 141.34 °C for 1.35 hours with pressure of 20 mmHg, the decrease of PV reached 51.89%, and it was obviously affected by contact duration.

4. Relationship between deodorization parameter and RPO quality

The research result showed that temperature and deodorization period was easier to control rather than vacuum pressure for deodorization unit used. Measurable working pressure reached by equipment was 5 mmHg but when N₂ gas began to flow, vacuum pressure was decrease to an operational average of 20 and 25 mmHg (-74 dan -73.5 cmHg vacuum). The trial stage for both vacuum pressure produced good performance mainly in reducing water content and peroxide value, maintaining carotene content in oil and reducing typical odor intensity of palm oil. In a range of temperature an contact period of 135 – 145 °C (408 – 418 K) and 1 – 4 hours, decrease of carotene retention (%) due to deodorization process equals to the logarithmic of absolute process time with the equation of “Carotene Retention (%) = -764 x ln(absolute temperature) + 4693” (Figure 2a) and process duration with the equation “Carotene Retention (%) = -7.81 x ln(process duration) + 91.02” (Figure 2b).



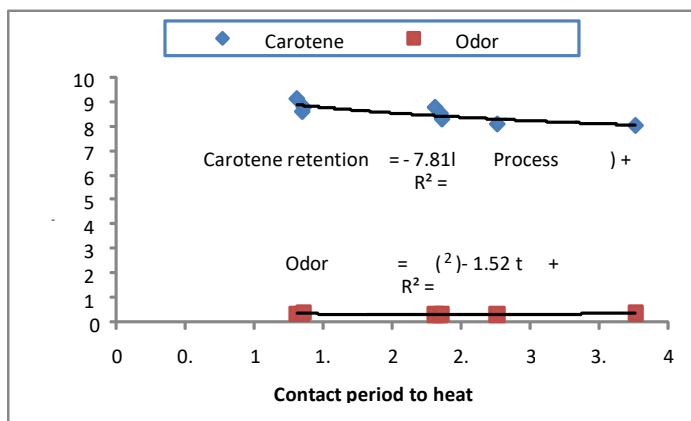


Figure 2. Relationship between carotene retention and odor intensity with process temperature and process duration with heating during deodorization.

Relationship between odor intensity and process temperature and process duration during deodorization in range of temperature and process duration 135 – 145 °C (408 – 418 K) and 1 – 4 hours, can be described as equation: “Odor Intensity = 0.08 x (squared absolute temperature) – 66.88 x (absolute temperature) + 13823” and duration process with the equation “Odor Intensity = 0.315 x (squared process duration) – 1.52 x (process duration) + 5.268”. (Figure 2b).

IV. CONCLUSION

Effective deodorization to produce RPO with the content of free fatty acid and peroxide value that met the requirements of SNI quality of carotene content above 400 ppm and odor scale below 3.3, were the combination of temperature (T) of 141.34 oC, heat process duration (t) of 2.35 hours and vacuum pressure of (P) of 20 mmHg. The resulted RPO contained free fatty acid and peroxide value of 0.11% dan 0.12 meq/kg oil respectively, total carotene of 444.09 ppm and odor value of 3.21

Deodorization with the range of temperature and process duration of 135–145 °C (408–418 K) and 1–4 hours have led to carotene retention decreasing (%) following the equation “Carotene Retention (%) = -764 x ln(absolute temperature) + 4693” and process duration with the equation “Carotene Retention (%) = -7.81 x ln(process duration) + 91.02”; and also resulted odor intensity with the equation “Odor Intensity = 0.08 x (squared absolute temperature) – 66.88 x (absolute temperature) + 13823” and duration process with the equation “Odor Intensity = 0.315 x (squared process duration) – 1.52 x (process duration) + 5.268”.

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