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Utilization of Used Cooking Oil from Street Vendor: Recycle and Anti-Oxidant Enrichment with *Moringa oleifera* leaves

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ABSTRACT. Used cooking oil (UCO) is abundant in Indonesia because of lifestyle of people. Especially UCO from street vendors had very low quality based on its Free Fatty Acid (FFA) content that reached 5.074%. When UCO was deposed into drainage, it would pollute the environment. Low grade UCO from street vendors contained Unsaturated-Fatty-Acid, Saturated-Fatty-Acid, and other hydrocarbons. Recycling UCO to replace edible oil considered more desirable rather than biodiesel since higher added value. FFA was the most undesired compound affecting cooking oil quality. FFA reducing with diluted 0.1 M NaOH 10% v/v could reduce FFA from 5.07% to 0.53%. Bleaching earth (BE) content mostly Si, Nb, Al, Ca and Na was safe to treat UCO for edible cooking oil. BE played cleaning UCO but absorbed the oil 17%. ANOVA analysis for BE and *Moringa oleifera* leaves (MOL) treatment fits with Reduced Quadratic model. Based on the ANOVA, the model showed that the decrease of FFA was determined significantly by BE amount and temperature with P-values less than 0.05. Optimization for BE treatment was done using Response Surface Method to find out the lowest FFA. And based on the simulation, it was obtained 0.2854% while the experimental results showed 0.2908%. Furthermore, BE combined with Moringa oleifera leaves (MOL) that known anti-oxidant source was used to treat UCO. UCO originally content stronger anti-oxidant activity rather fresh palm oil with IC_{50} 62.12 and 83.03 mg/kg, respectively. Stronger anti-oxidant in UCO allegedly derived from fried foods. Treatment 10% BE and 5% MOL considered optimal for good appearance edible oil, little yellow greenish. Moreover, GC/MS analysis showed improvement active compounds in treated UCO with 5, 7.5 and 10 g MOL in 150 ml UCO with 24.36%, 30.32% and 37.76% active compounds, respectively. Moreover, anti-oxidant measured with IC_{50} the treated UCO were 43.18, 42.33 and 41.78 mg/kg, respectively. Increasing the number of MOL did not significantly increase the anti-oxidant activity. Anti-oxidant detected in treated UCO identified such as ethyl acridine, indolizine derivatives, cyclotrisiloxane-hexamethyl, benzimidazoles, and Fumaric acid. Based on the results, UCO recycling is applicable for a community, save expenses and strengthen food security and food sovereign. Further thought for its implementation is to design an integrated system from collecting UCO in a reservoir tank equipped with filter, recycling process and finally product tank at mini plant scale.

Keywords: Anti-oxidant enrichment, bleaching earth, edible treated UCO, *Moringa oleifera* leaves (MOL) , UCO recycle.

INTRODUCTION

Used cooking oil (UCO) is abundant in Indonesia since the lifestyle that favors fried food, either as main food or snack. Some UCO categories still in good quality, for example UCO from fancy restaurant while low quality UCO got from street vendors. UCO from fancy restaurants reached 9.720 million L in a year (Perdana, 2021). Unfortunately, every 10.000 kg UCO if disposed without any treatment directly into environment, consequence to recovery the environment is costly, around IDR 7.2 billion (Inayati et al., 2021). In addition, survey at 2 private hospitals and 8 street vendors gain 18 and 15 L/day, respectively.

The impact of dumping UCO into the environment like disposed on drainage will pollute the water, blockage of waterways and eventually become breeding grounds for bacteria that cause disease (Almagribi et al., 2022). UCO contained organic matter which results in an increase in COD and BOD. The oil will spread wide as thin layer and cover the surface of the water so that air cannot infiltrate into water so that dissolved oxygen got very less and anaerobic microbes grow. An-aerobic microbes usually produce unpleasant odor (Prasetyo et al., 2020). Some metals were also detected contained in the oil resulting from the previous frying process (Callano, 2012).

If this UCO is still used for cooking, high saturated fatty and glyceride would affect for healthy such as cancer, heart disease and decreased fat digestibility (Ganesan et al., 2020). Some metal content in UCO depends on the use of food that fried. Pollutant in UCO was detected like As, Cd, and Hg. Cd binds to mitochondria and inhibit both cellular respiration and oxidative phosphorylation (Rahimzadeh et al., 2017). Cd effects cell proliferation, differentiation, and apoptosis with further effects could kidney failure and other diseases.

Low grade UCO contained high FFA level. Treatment of UCO due to reducing FFA, to proceed UCO as raw material for biodiesel by transesterification method (Prasetyo et al., 2024). Another UCO utilization was to be converted to green diesel with inorganic catalyst (Murti et al., 2020). Transesterification is considered as the simplest method for biodiesel conversion (Zahan et al., 2018). Unfortunately, the price of biodiesel was economically infeasible since the price of diesel in Indonesia is still subsidized by government IDR 6.800 or USD 0.45 per L. Therefore, UCO price and operational cost could not be covered.

Moringa oleifera leaves been known to contain very strong antioxidant with IC_{50} less than 5 mg/kg (Susanty et al., 2019). Natural antioxidants could replace synthetic antioxidants and utilized to enhance nutritional profile in cooking oil. Especially antioxidant derived from plant compounds. Some antioxidant types that present in plant like carotenoids, flavonoids pro anthocyanidins, and coumarins have plays a major role in protection against oxidative damage (Chatterjee et al., 2022). Enrichment edible oil by active compound could improve edible oil quality.

This study was conducted based on the increasing number of UCO in communities and the character of the communities who usually just threw UCO in waste channel. This habit can cause environmental pollution and public health as well. This work aims to provide input for utilizing UCO by recycling. Recycling low-grade UCO to replace bulk cooking oil offers higher added value rather than biodiesel, which is IDR 14,000 or USD 0.9, respectively (Rahayu, 2022). UCO from street vendors was processed in several stages, starting with filtering coarse impurities, reducing FFA, and refining-enriching UCO with Bleaching Earth (BE) and Moringa oleifera leaves (MOL) to increase anti-oxidant. The processed used cooking oil is explained to see whether the processed used cooking oil meets Indonesian requirements as edible cooking oil.

EXPERIMENTAL SECTION

Material

Low grade UCO was provided by some street vendors. UCO was collected and mixed first to provide the uniformity UCO during this work.

Technical grade sodium hydroxide (NaOH) and BE could be obtained in common market. 48% NaOH solution was diluted according setting parameter research design. Potassium hydroxide (KOH) provided by Merck was used for analysis purpose.

Standardization of Solution NaOH and KOH

NaOH and KOH were deliquescent (absorbs moisture from the atmosphere). NaOH and KOH solutions that have been made at certain concentrations were standardized first using primary standard $H_2C_2O_4.2H_2O$ (oxalic acid) solution.

Research Design

Determination of the combination of parameters in this research was assisted by Expert Design Stat Ease 360 software. This research design was intended to obtain optimization of research parameters that produced the lowest FFA and the highest yield.

FFA Reduction

Low grade UCO was filtered to removed coarse dirt with filter paper. Subsequently, 150 ml UCO was mixed with 150 mL distilled water. The 2-phase solution, water, and oil, was stirred slowly and gradually titrated by 0.1 M NaOH with various amount 5, 7.5, and 10 %. Stirring was set slowly to avoid excessive saponification. Any other dissolved impurities were also dissolved in NaOH solution. Finally, water-oil solution was separated by separatory funnel.

Bleaching Earth (BE) Treatment

BE treatment was conducted to absorb the rest impurities in UCO including gases (Prasetyo et al., 2020). Expected impurities absorbed was metals since unpredictable food fried. BE had important role in clarifying the oil. Made the color lighter and yellowish. Treated UCO also checked any metals that possible dissolved from BE using AAS.

Treatment UCO with BE and MOL

BE used was 10 g in 150 ml UCO and combined with MOL to treat UCO. MOL was varied 5, 7.5 and 10 g in 150 ml UCO. This UCO treatment was stirred and varied temperature started at 50, 60 and 70°C. Treated UCO was analyzed its FFA to control the quality and the components with GC/MS as well.

Analysis

FFA was analyzed by weighing 5 gr sample in 50 ml of 70% ethanol. 5 drops of phenolphthalein (PP) solution and titrated with 0.1 M NaOH until the color turn pink and stable for 10 minutes. FFA in % is determined using the underlying equations:

$$FFA\ (\%) = \frac{((mL\ of\ titrant)x\ (N) of\ titrant)\ x\ molecular\ weight_{average}}{weight\ of\ sample\ in\ gram} \quad (1)$$

Pelican oil analysis was carried out in order to observe if mineral oil still exist. The mineral oil cannot be saponified in alcohol-water base solutions. The presence of pelican oil made the solution cloudy.

1 ml sample was put into 25 ml of 95% ethanol and added with 1 ml of 0.5 M KOH. The solution was stirred occasionally and boiled for saponification, approximately 5 minutes. Afterward, 25 ml of distilled water was added.

Scanning electron microscope (SEM) analysis. The morphology of BE was scaned after and before BE utilized with SEM apparatus JEOL model JSM-6390 that equipped by Energy Dispersive X-Ray spectrometer (EDS) to notify any elements content and distributed on the surface BE.

Atomic Adsorption Spectroscope (AAS) equipment is Agilent 5800 ICP-OES (Prasetyo et al., 2023). AAS would detect some metals. Metal in samples were converted into aerosol form by argon gas in nebulizer at plasma temperature. The samples would be excited and back to initial state while emitting irradiation dispersed and turned into electrical signal. Magnitude electric signal was proportional to the light emitted with element concentration.

Gas chromatography - Mass Spectrometry (GC/MS) analysis. GC/MS analysis was conducted to identify any compounds in a sample of oil. Identification for volatile constituents in the oil was performed using an Agilent 7890B series GC coupled with a 5977A mass spectrometer detector. Component's separation was accomplished with an Agilent HP-5MS capillary column, 5% of phenyl)-methyl-polysiloxane phase, which had dimension 30 m length, 0.25 mm I.D. and 0.25 mm thickness). Helium (He) was the gas carrier with flow rate of 1 mL min-1. Sample was prepared as follow: 100 µL sample added with 800 µL DiCloro-Methylene (DCM) and 100 µL Bis-Trimethylsilyl Trifluoroacetamide (BSTFA). The solution was heated at 60-70°C for 30 minutes. One µL of sample was automatically injected into GC/MS system using split less mode with inlet temperature maintained at 250 °C. GC oven temperature was initiated at 40 °C for 1 min, then gradually increased to 300 °C at a rate of 10 °C min-1 and kept constant at 300 °C for 4 min. The MS detector was operated in Electron Impact (EI) mode with ionization energy of 70 eV. Transfer line of MS source and MS quadrupole temperature were maintained at 270, 230, and 150 °C, respectively. MS analysis was conducted in fully scan mode in the mass range of 30/600 m/z (Septama et al., 2022). Detected compounds reviewed by calculating the RI. The compound mass spectral was compared with the results of the RI values corresponding data from National Institute of Standard Technology (NIST) 17 library and NIST Chemistry. n-alkane standards consisted of C_8H_{18} - $C_{23}H_{48}$ was injected with the same GC/MS method. The alkane retention times were the basis for RI value calculation with equation 2.

$$RI = 100(n + \frac{t_{r(x)} - t_{r(n)}}{t_{r(N)} - t_{r(n)}}) \quad (2)$$

n represented carbon number of alkanes eluted before target compound.

tr(x) indicated the retention time of the target compound.

tr(n) and tr(N) correspond to retention time of eluted before and after target compound. The relative amount of volatile compound was used to estimate percentage of peak area from chromatogram.

Analysis of anti-oxidant absorbed by treated UCO from MOL during recycling process. As much as 100 ml UCO and 70% ethanol was stirred at 37 °C for 3 hours. Afterward, ethanol and oil were separated with separatory funnel. Ethanol that absorbed the anti-oxidant was evaporated in oven at 60 °C for 24 hours. Anti-oxidant activity was measured with 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. Treated UCOs was extracted its anti-oxidant with 70% ethanol by mixing at 37 °C for 3 hours. DPPH solution was prepared in ethanol and subsequently added to various concentrations 1, 5, 10 and 20 mg/kg. Absorbance was read at 517 nm. Quercetin 20 mg/kg was used as standard. These measurements were performed in duplicate and percentage of inhibition was calculated using equation 3.

$$IC_{50} = \frac{(A_b - A_s)}{A_b} x\ 100\% \quad (3)$$

RESULT AND DISCUSSION

The work began by analyzing UCO that already collected for series of experiments that would be carried out. Therefore, UCO was uniform for one package research series. Fatty acid of UCO was compared with fresh PO that refers to the processing of the mesocarp PO tree (*Elaeis guineensis*). Fatty acids are grouped into 2 categories, saturated and unsaturated. PO content mostly comprised of palmitic acid, oleic acid, and linolenic acid by 44.00%, 41.20%, and 8.00%, respectively. PO is vegetables oil that consists of Long Chain Fatty Acid (LCFA) with monocarboxylic acids and total hydrocarbon chain length more than 12 total carbon atoms (Schönfeld et al., 2016). Linoleic acid and linolenic are known as omega 6 fatty acids and omega 3 as essential fatty acids shown in **Table 1**.

Free fatty acids (FFA) are formed by hydrolysis and oxidation of oil. The existence water, including humidity, accelerates the hydrolysis of the oils. FFA content is indicated by acid number (Irawan et al., 2013). To maintain the uniformity of UCO during this work, UCO was collected in sufficient quantities. Furthermore, the UCO was analyzed the FFA and reached 5.074%, much higher than tolerable FFA for edible oils.

FFA Reduction.

First of all, the collected UCO was filtered to separate the coarse dirt before being stored in a tank. Further treatment was carried out by saponification which expected to separate dissolved impurities and to reduce FFA as well. However, this saponification was done very slowly to avoid excessive saponification (prasetyo et al., 2024). Optimization the use of 0.1 M

NaOH was carried out at water-UCO ratio = 1:1. Two-phase oil-water stirred slowly and dropped by 7.5% volume NaOH 0.1 M was considered the optimal. FFA decreased from 5.07% to less than 1% (data not shown). Afterward, water-UCO separation with separator funnel, the visual UCO changed from dark brown to yellowish but still cloudy.

Fatty acids in UCO were more varied than PO. More medium chain fatty acids (MCFA) were identified. The formations of shorter fatty acids were influenced by frying process that reached 170°C (Nazarena et al., 2022). Most of the unsaturated fatty acid like oleic and linolenic acid decreased and even undetectable due to the high temperature process. As for linolenic acid and oleic acid were partially cracked and oxidized to shorter saturated fatty acid like caprylic acid and lauric acid.

In other words, comparison of fatty acid between PO and UCO, frying process changed the composition of fatty acid in PO. Palmitic acid decreased 60% and partly into shorter SFAs as indicated by increasing 27% oleic acid. A shorter SFA was also formed, although very small amount like caprylic acid and Capric acid. Another effect of frying, all MUFA and PUFA decreased because MUFA and PUFA also oxidized to saturated and cracked as well.

Bleaching Earth Treatment.

BE has been known as absorbent in Palm Oil to adsorb to clarify, absorbing impurities and cleaning the color of vegetables oil. The working temperature is about 90 °C (Soetaredjo et al., 2021). To adjust with next stage, combining with MOL extraction, the BE treatment was carried out at 60 °C.

Figure 1A showed morphology of origin BE at magnificent 500x and detected components by EDS. In organics detected Si, Nb, Al, Ca, and Na at level 51.11%, 11.43%, 8.84%, 3.59%, and 2.14%, respectively. According government regulation SNI 3741:2013, no harmful inorganic in BE so that BE was safe material to treat UCO. Moreover, metals that could be imbalanced charges exchangeable as well as water molecules held together by ion-dipole forces like Fe, Mg, and Mn were not detected (Callano, 2012).

After UCO was treated with BE, some oil was sticked on the surface of BE. The oil was not vaporized at 70 °C but at 300 °C. Many components detected more in **Figure 1B** indicated that the components were part of UCO. However, after regeneration at 300 °C, some components could be detached from the surface of BE. The detected Si, Nb, Al, indicated that the metals can only be oxidized at higher temperatures, 660, 450 and 400 °C, respectively (Laurent et al., 1991; Sheasby, 1968; Smeltzer, 1956).

Treatment using BE was intended to improve visual quality of UCO become clearer. Response surface method was used to determine BE requirement and temperature. **Figure 2**, showed FFA was less 1% in all various treatment. FFA reduction further decreased at this stage and visual UCO got clearer.

Statistic analysis delivered by Analisa of Variant (ANOVA) showed significance of experimental parameter settings. Parameter F-value of 83.48 implied signal-to-noise ratio that compares variance between groups, BE and Temperature, was significantly difference. The model was significant difference which means that the determination of the experiments level provided a significant difference among the levels. Quantitative measurement F-value at 83.48 also interpreted that only 0.01% chance that F-value could occur due to noise.

P-values that less than 0.05, BE and Temperature at order one and two, indicated significant model, the terms was counting those required support hierarchy. P-values showed significant effect of BE and temperature at FFA reduction.

Table 1. Fatty acid in PO and UCO

Fatty Acid Component	Carbon Length	Content (%)	
		PO (Japir et al., 2017; Rahman et al., 2022)	UCO
Saturated Fatty Acid (SFA)			
Caprylic acid	C8:0	nd	0.749
Capric acid	C10:0	nd	0.876
Lauric acid	C12:0	0.10	27.337
Myristic acid	C14:0	1.00	3.097
Palmitic acid	C16:0	44.0	17.602
Stearic acid	C18:0	5.00	1.550
Arachidic acid	C20:0	0.10	nd
Mono Unsaturated Fatty Acid (MUFA) and Poly Unsaturated Fatty Acid (PUFA)			
Palmitoleic acid	C16:1n9	0.10	0.113
Oleic acid	C18:3n3	41.20	16.213
Linolenic acid	C18:1n9	0.50	nd
Linoleic acid	C18:2n6	8.00	2.078

Note: nd means not detected

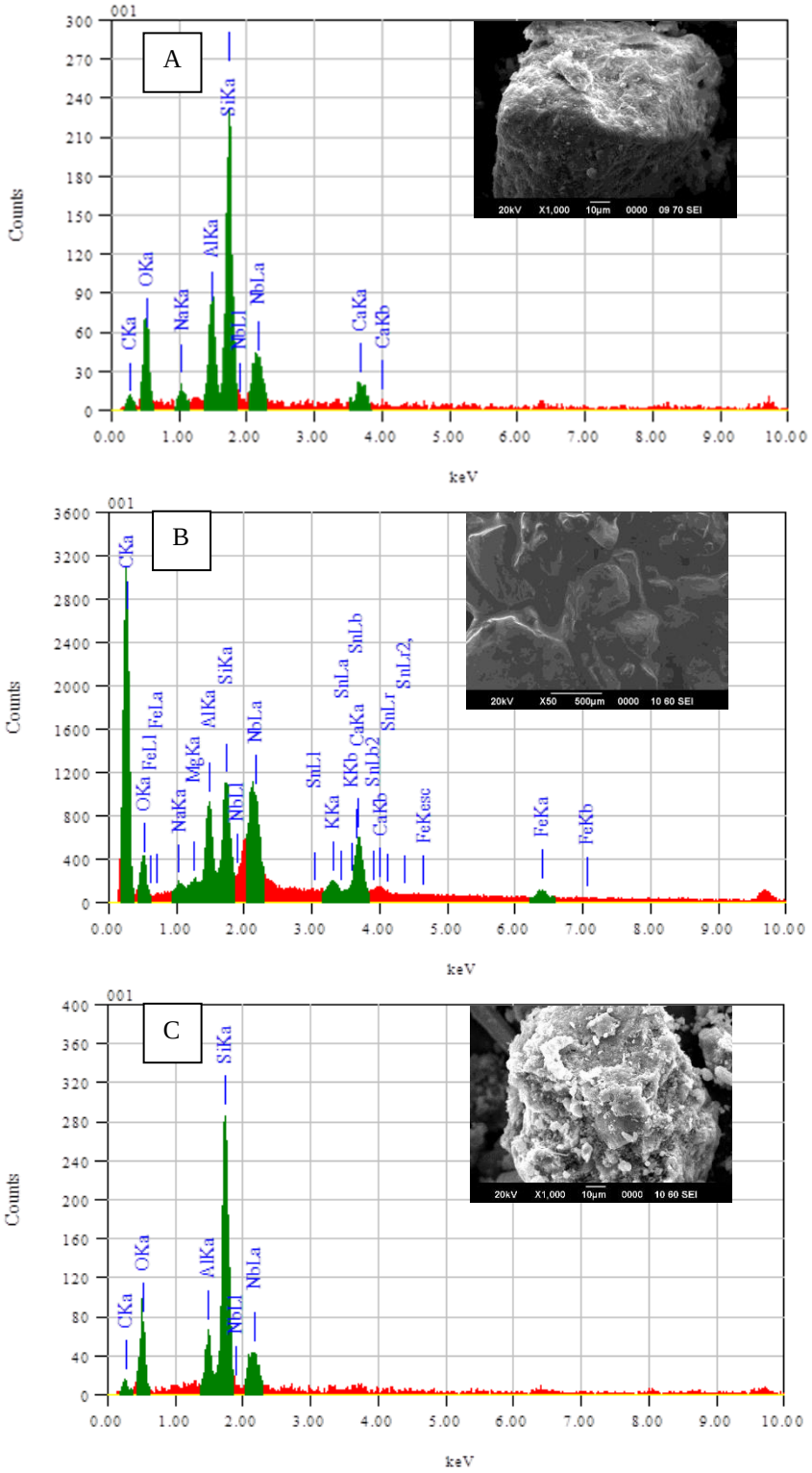

Figure 1. Treated UCO by BE analysis SEM and EDS (**A**) BE Image before process, (**B**) BE after used for UCO treatment, (**C**) BE after regeneration.

UCO was suspected containing gas and organic compound from frying of food (Prasetyo et al., 2020). BE had a role in absorbing gas. Unfortunately, some UCO was absorbed by BE as so that reduced the yield (Abdelbasir et al., 2023). To minimize UCO loss, 10 gr BE was considered as the optimal number. Based on simulation, 10 gr BE caused 17% UCO loss.

BE absorbed all fatty acid evenly as shown on **Table 3**. In comparison between commercial PO and treated UCO with BE, the existence short chain fatty acid was remained in treated UCO. Existence of short chain fatty acid gave many health benefits such as anti-inflammatory, immunoregulatory, anti-obesity, anti-diabetes, anticancer, cardiovascular protective,

hepatoprotective, and neuroprotective activities (Xiong et al., 2022).

For food security, any metal in UCO was measured with AAS. Comparison among origin UCO, after FFA reduction and BE treatment was shown at **Table 4**. Wide various metals were detected K, Na, Ca, Mg, Cu, Cr, Zn, Fe, Mn, Cd, Ni, Pb and As depend on what kind of food was fried (Fathollahy et al., 2021; Raji et al., 2021). In this work used local UCO and not many various metals detected. As a report, metals that detected outside of what was generally detected by other researchers is B, Ba, and Se. Meanwhile, the presence of Fe, Cu, and Zn were not taken into account because of already contained in fresh PO. Fe were naturally that existed from PO, also presented in palm oil empty fruit bunches (EFB) (Prasetyo et al., 2024).

Enrichment Antioxidant UCO with *Moringa oleifera* Leaves (MOL)

The last method in UCO recycling process was to enrich active compounds as added value to UCO recycling. MOL was added at UCO clarification. MOL is known containing anti-oxidant like flavonoids and tannins. Antioxidant has roles and is useful as active compounds like anti-inflammatory, anti-bacterial or anti-cancer (Petri et al., 2021). Therefore, MOL was added at clarify step, combined with BE, to enrich UCO with antioxidant. Determination temperature variation for extraction of active compound from MOL was carried out at 50, 60 and 70 °C to obtain optimal product like flavonoid since extraction at higher 80°C caused reducing extraction productivity itself (Wei et al., 2023). As a visual result of BE and MOL treatment turned out clearer and yellowish UCO.

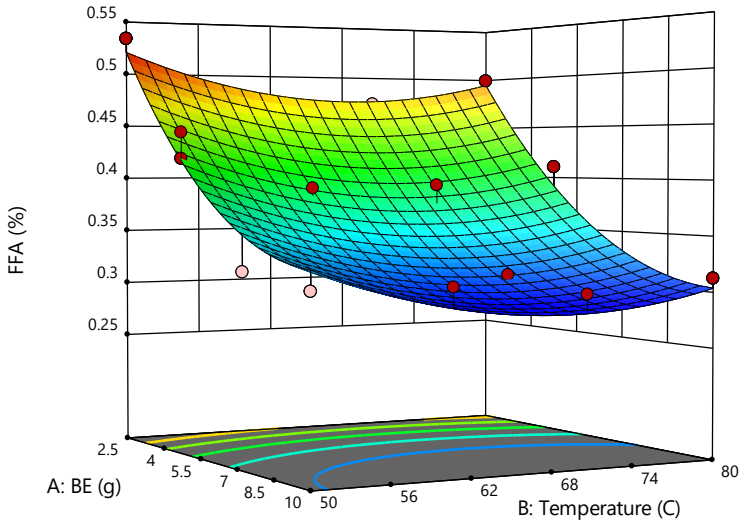

Figure 2. 3D Surface response of FFA BE treatment at varied temperature .

Table 2. ANOVA of treated UCO in quadratic model for FFA reduction response

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.1329	4	0.0332	83.48	< 0.0001 significant
A-BE	0.1023	1	0.1023	257.08	< 0.0001
B-Temperature	0.0018	1	0.0018	4.47	0.0505
A^2	0.0079	1	0.0079	19.89	0.0004
B^2	0.0038	1	0.0038	9.45	0.0073

Table 3. Fatty acid of UCO after BE

Compound	UCO (%)	BE (%)
Caprylic acid	0.749	0.540
Capric acid	0.876	0.420
Lauric acid	22.953	21.987
Myristic acid	3.097	1.760
Palmitic acid	17.602	9.893
Stearic acid	1.550	0.819
Oleic acid	16.213	8.836
Linoleic acid	2.078	1.119

Table 4. Comparison of metals content in UCO treatment

Sample	UCO (mg/L)	NaOH Washing (mg/L)	Bleaching Earth (mg/L)
As	0.002000	0.004.415	0.002355
B	0.000267	0.000515	0.000201
Ba	nd	0.000457	nd
Cr	0.001171	0.001114	0.000998
Cu	nd	0.000584	nd
Fe	0.080228	0.131750	0.075665
Mn	0.013125	0.017061	0.011338
Ni	0.005760	0.007629	0.005778
Pb	0.000667	0.000258	0.000301
Se	0.000106	0.000014	0.000104

Note: nd means not detected

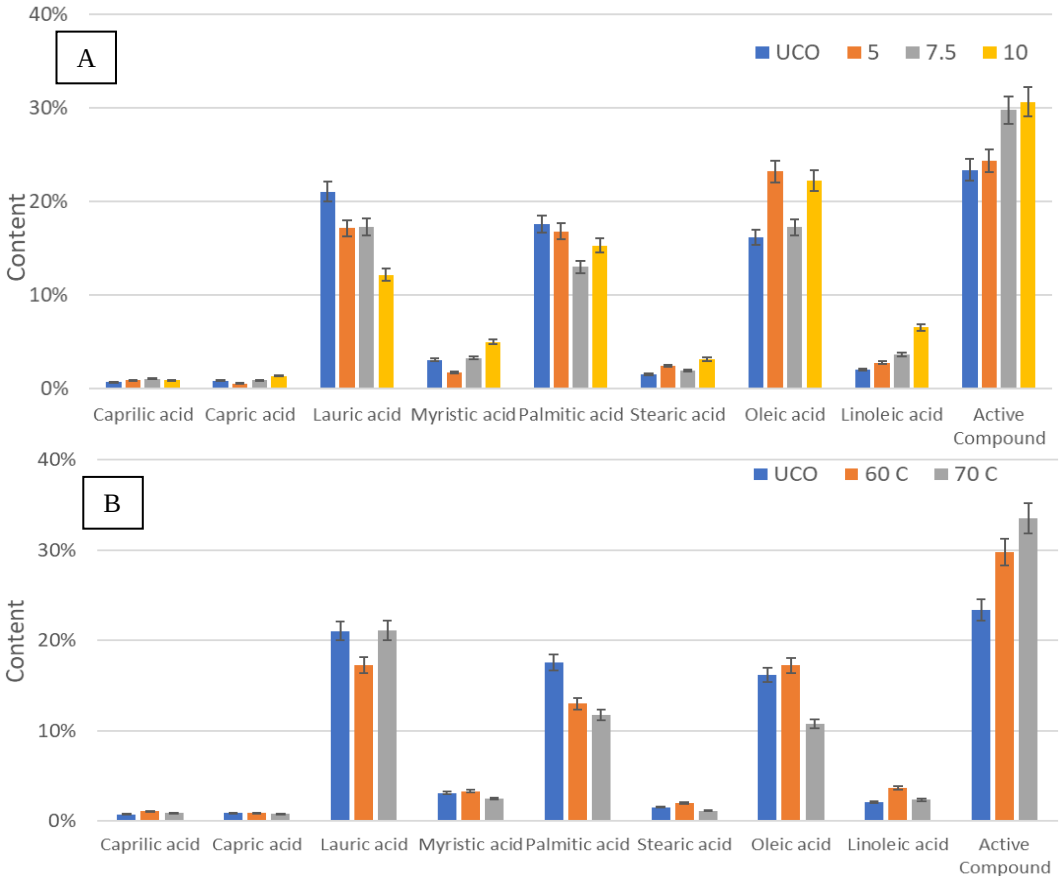

Figure 3. Profiling treated UCO with BE and various *Moringa oleifera* leaves (**a**) various MOL (5, 7.5, 10 g in 150 ml at 60°C, (**b**) various temperature at 10 g MOL addition.

Compiling GC/MS data of treated UCO with BE and MOL showed shifts fatty acid due to MOL addition. UCO already contains antioxidants and identified in GC/MS data. The antioxidant was obtained from types of food fried beforehand. Oleic acid in MOL was very high, reaching 67.3%. Therefore, treatment with BE and MOL caused oleic acid content continues to increase. MOL also contains a little palmitic acid, 8%. However, BE tended to absorb more the fatty acid so that palmitic acid content was somewhat reduced. While myristic acid and stearic acid were small in UCO. When MOL also contained both fatty acids, it appeared to show an increase. Lauric acid, which is quite large in UCO, decreased significantly due to absorption by BE, whereas lauric acid was not detected in MOL (Omonhinmin et al., 2020).

UCO can be enriched the active compound of MOL by 76%. Omega 6 which was abundant in linoleic acid was very useful although the increase is only around 1%. Some active compounds that were successfully identified in UCO recycling include ethylacridine for anti-inflammatory, indolizine derivatives for anti-cancer, cyclotrisiloxane-hexamethyl and Benzimidazoles for anti-microbial,

and Fumaric acid for anti-oxidant (Özcan et al., 2020).

Compiling types of compounds that were classified as active substances in treated UCO was shown at **Figure 3**. The addition of 5, 7.5 and 10 g MOL turned out to be linear with the increase in active compound by 24.36%, 30.32%, and 37.76%, respectively. When the temperature of UCO treatment was increased from 60 to 70°C, **Figure 3B**, active compounds significantly increased as well by 29.77 to 33.58%, respectively. Visual observations of treated UCO with BE and MOL showed clearer. However, to much MOL addition made treated UCO greenish and aesthetically unattractive to user.

Anti-oxidant levels

Commercial PO analysis showed anti-oxidant activity in medium level, IC_{50} 83.03 mg/kg. Measured antioxidant was anti-oxidants contained in PO extracted in 70% alcohol, rather than total antioxidants in PO using HDDP method. At the step of FFA reduction, visual of UCO got better but still cloudy. Surprisingly, anti-oxidant in the UCO showed higher than PO. The activity was in medium with IC_{50} 62.06, depending on the type of food that fried previously. Clarification of UCO with BE only resulted in clearer UCO visual while the antioxidant was not reduced. The addition of MOL, which is well known with very strong anti-oxidant in clarifying UCO with BE, was carried out to improve the quality. Treated UCO with MOL for 5, 7.5 and 10 g showed increasing anti-oxidant at strong level with IC_{50} 43.18, 42.33 and 41.78 mg/kg, respectively. This activity was much lower if MOL directly extracted with 70% ethanol that reached 4.3 mg/kg (Susanty et al., 2019). Treatment with 5 g MOL considered the optimal amount because more MOL, 7.5 and 10 g did not give higher anti-oxidant level.

Standard Quality Cooking Oil

Indonesia standard quality of edible oil is regulated by SNI 3741:2013. Clarification of treated UCO in overall is shown at **Table 5**. Treated UCO was fulfilled the requirements of SNI 3741-2013. Additional testing by heating up treated UCO at 170 °C did not show any smoke that could be seen visually.

Table 5. Quality of used cooking oil at every treatment

Parameters	Unit	SNI 3741-2013	UCO	FFA Reducing	Treated UCO
Smell	Normality	Normal	Abnormal	Abnormal	Normal
Color	Color	Yellow/Pale	Black	Light brown	Yellow
Water content	%	max. 0.15	0.13	0.086	0.048
Acid Value	mg NaOH/g	max. 0.6	3.1974	0.6349	0.587
Pelican Oil	Qualitative	Negative	Negative	Negative	Negative
FFA	mg/L	max. 20	50.740	8.78	10.42
Yield	%	-	-	66.6	52.5
s.g.	-	0.9	0.8680	0.8710	0.9260
Viscosity	mm^2/s	max. 48	36.5120	40.6848	41.4672
Cd	mg/kg	max. 0.2	nd	nd	nd
Pb	mg/kg	max. 0.15	0.00067	0.00026	0.00096
Hg	mg/kg	max. 0.05	nd	nd	nd
As	mg/kg	max. 0.1	0.00206	0.00442	0.002527

Note: nd means not detected

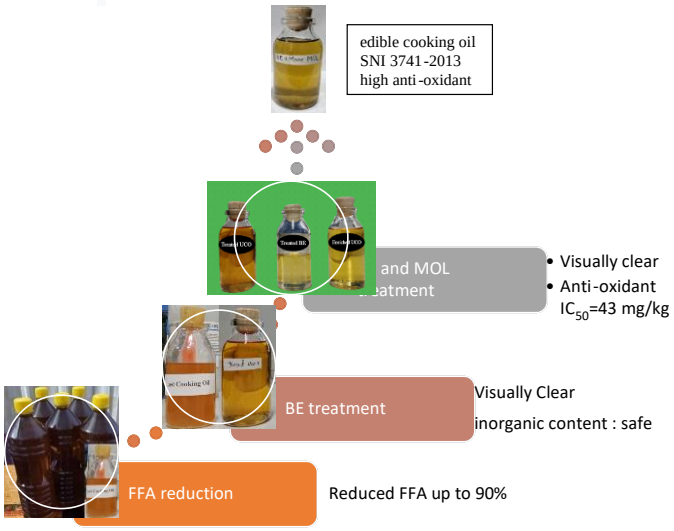

Figure 4. Visualization stages of UCO treatment, role in each step.

CONCLUSIONS

FFA content greatly affected edible oil quality, the most essential consideration in edible oil refining. High FFA will lead further oxidation and affect taste and flavor of PO. The work of UCO recycling showed its possibility by paying attention to the quality as PO. Other priors were including observing its suitability and assessing if the treated UCO was safe. As shown on **Figure 4**, the process breakthroughs carried out to achieve UCO recycling fulfilled the regulation of PO. The proposed process stages begin with starting from FFA reduction that reduced up to 90% FFA. Further step, 10 gr BE and 5 g MOL treatment at 60 °C considered optimal with active compound 29.77% and reached anti-oxidant IC_{50} 43.18 mg/kg, very strong activity. Visual observations showed clear UCO recycling by mixing BE and small amount MOL. UCO recycling fulfilled standard quality for edible as regulation SNI 3741:2013, even this process provides added value by increasing anti-oxidants.

Based on the results that have been achieved, the research can be continued by conducting socialization to the community. Thus, the community can practice, save expenses, and strengthen food security independently. Further thought for its implementation at bigger scale is to design an integrated system starting from collecting UCO in a reservoir tank equipped with filter, recycling process and finally product tank at mini plant scale.

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