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Improved of color properties on *Sardinella lemuru* oil during adsorbent refining using magnesol xl

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Abstract

Magnesol XL concentration (0.5, 1, 3 and 5%), heating temperature (25, 50, 70 and 90 ˚C) and time (5, 10, 15 and 20 mnt) during purification to the color properties (Lightness L*, redness a* and yellowness b*) of *Sardinella lemuru* oil were evaluated. Purification using Magnesol XL in any condition effectively increase the L* and a* value but reduced the b* value of the lemuru oil. Highest L* value (96.57) was achieved at the treatment temperature 90 ˚C, 5 % level of Magnesol XL concentration and 5 minutes process. Lowest a* value (more green color) was obtained at treatment 70 ˚C temperature, 5% level of concentration and 15 minutes, then lowest b* value was obtained at treatment 90 ˚C temperature, 5 % concentration and 5 minutes process. All the refined lemuru oil's result had a hue angle higher than 90˚ representing the light greenish-yellow color.

Introduction

Color properties have significant effect for consumer acceptability especially at edible product beside its nutritional value and sensory properties. At consumer's consideration, the color of food will directly shows the quality, the maturity (for fruits and vegetables) which lead to customer expectation, like or dislike to its preference and acceptability. Not only that, the color of product also had important consideration among the technologist. The color properties indirectly show the consistency, the stability and the composition of product and also lead to the problem solving for enhancement of its appeal and appearance to meet the customers need (Francis, 1999).

Processing plant in East Java, Indonesia produces 10,000 tons of crude lemuru (*Sardinella lemuru*) oil annually as a by-product from the processing of fish meal (Department of Marine and Fisheries, Indonesia, 2011). This unrefined lemuru oil is still used as an animal feed ingredient in Indonesia now. It contains soap stock, high contents of primary and secondary lipid oxidation products have been the problems associated with color, odor, flavor, and other impurities.

Adsorbent refining is the common technique to enhance the quality of edible oil. The positive outcome of the ability of the adsorbent to adsorb the impurities (free fatty acids, gums oxidized component and color pigments) were previously studied by Giiler and Fatma (1992), Lin *et al*. (1998), Maes *et al*. (2005), Eyub and Celik (2005), and Battacharya *et al.* (2008). Adsorbent was usually used at bleaching process to remove color pigments which it was an undesirable compound at the oil (Ketaren, 1986). Magnesol XL already used to improve quality of sunflower, cottonseed, soybean and palm oils. It contained Si (34.75%), Mg (27.33%), Ca (4.36%), Na (1.92%) and Fe (1.09%) (Farag and El-Anany, 2006). Adsorptive bleaching is often used commercially to improve fish oils by removing colored matter and natural pigments. In addition to the removal of colored compounds, adsorptive bleaching improves the brightness of oils by removing the suspended mucilaginous and colloid-like matter (Gauglitz and Gruger, 1965), This study

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was aimed to evaluate the color properties of lemuru oil at several different refining condition affected by various levels of concentration, temperature and time.

Material and Methods

Materials

Lemuru (*Sardinella lemuru*) oil was obtained from fish meal processing plant at East Java, Indonesia, as the by-product of fish meal production. The lemuru oil was frozen and kept in ice box during transport to experiment place (Food Technology Division, Schoool of Industrial Technology, Universiti Sains Malaysia). The lemuru oil was then stored at freezer (-20˚C) until analyzed. The Magnesol XL was obtained from Magnesol Product Division, Reagent Chemical and Research, Inc., Houston, Texas, 77 016, USA. It has hydrous, white, amorphous and odorless characteristic.

Lemuru oil refining

Alkali refined lemuru oil was centrifuged at speeds 5000 rpm for 30 minute, which was the best treatment for removing soap stock and polar compound according to according Suseno *et al*. (2011). Then it was mixed with magnesol XL adsorbent 1, 3 and 5% (w/w) level for 5, 10, 15 and 20 minute at 25, 50, 70 and 90˚C. Then, the oil was centrifuged at 10,000 rpm for 30 min to separate it from adsorbent. The color properties of the fish oil samples were analyzed before and after treatment.

*CIE-L*a*b* color measurement*

The color of lemuru oils was determined using a Colorimeter Minolta CM-3500d (Minolta, Spechtrophotometer, USA) based on the method of Shativel et al. (2003). The results were expressed as L*, a*, and b* values. L* values measure lightness (0 = black and 100 = white); a* values represent redness (+) and greenness (-); b* values represent yellow (+) and blue (-). The actual color is represented by hue angle, h = [tan−1 (b*/a*)] and chroma (the intensity of the color) was measured by C*=[(b*2 + a*2)1/2]. Total color difference (ΔE) was calculated by [(ΔL*2 + Δa*2 + Δb*2)]1/2 using refined Cod liver oil (Seven Seas Ltd., England) as a reference.

Statistical analysis

Data obtained from analyses were analyzed by Factorial Complete Randomized Design ANOVA and followed by Duncan Multiple range test carried out by SAS (Statistical Analysis System) software version 8.02 (SAS Institute Inc., USA) at 95% confidence level.

Result and Discussion

Initial L*, a*, b* values of raw lemuru oil were 91.43, -1.16, 49.30 respectively indicated light yellowish color. Purification using Magnesol XL in any condition effectively increased L* value and reduce the a* and b* value of the lemuru oil (Table 1). The highest L* value was achieved at 96.57 with 90 ˚C temperature, 5 % level of concentration and 5 minutes process. The increased L* value during fish oil adsorbent-purification also had reported by Huang and Sathivel (2010), which result the increasing of L* value from 27 to 34.6 with chitosan and from 27 to 42.1 with activated earth at 15 minutes process at salmon oil purification.

According to Gauglitz and Gruger (1965), the adsorbents remove the suspended mucilaginous and colloid-like matter so the brightness of the oil is improved. As shown at Figure 1, the L* value of lemuru oil significantly increased as the increasing of Magnesol XL concentration. At the same level of concentration, the longer the process result the higher L* value means that the activity of the adsorbent was increased especially for low temperature (25 ˚C). Implementation of higher temperature also effectively increased the ability of adsorbent to improve L* value of lemuru oil. Except for 90 ˚C temperature, the L* value at 5 minutes process was higher than 20 minutes process. The reduction of L* value at oil from light color to brown color usually occur when oil were heated at frying or high temperature condition, this condition can be affected by oxidation, polymerization and other chemical change (Maskan, 2003). Usually, the bleaching process of vegetable oil was carried out by high temperature, i.e. 90 ˚C – 110 ˚C with bleaching earth for soybean oil (Oliveira and Porto, 2005), 150 ˚C for frying oil by activated carbon, britesorb and magnesol (Battacharya *et al*., 2008). But, due to the different oxidative stability between vegetable-based oil and fish-based oil, (since the fish oil had high concentration of PUFA that more chemically reactive (Francis, 1999), the bleaching process for fish-based oil were implemented at less than 100 ˚C. According to Gauglitz and Gruger (1965), it was used at 20 ˚C – 92 ˚C on Menhaden oil bleaching, and Shativel *et al*. (2003) bleached the neutralized Catfish oil at 700^{0}C by activated earth. Lower temperature treatments on oil at long time also prevent the losses of antioxidant compounds that decreased the oxidative stability of oil (Allouche *et al*, 2007).

The lower a* value of refined lemuru oil reached at 70 ˚C, 5% magnesol XL and 15 minutes process (-3.39) (Table 1). Due to the initial a* value (-1.16), all the treatment condition result the more greenish

Table 1. CIELab Analysis Result of Lemuru oil refining

Treatment			L*	a*	b*		Chroma	AE
Temp.	Conc.	Time						
	Untreated		**91.43**	**-1.16**	**49.30**	**91.34**	**49.31**	**32.71**
25	0.5	5	92.03^{l}	-1.45^{b}	$\mathbf{47.72^{a}}$	91.74^{G}	47.74^{a}	$\mathbf{31.03^{a}}$
25	0.5	10	92.12^{H}	-1.49^{bc}	47.53^{ab}	91.80^{G}	47.55^{ab}	30.83^{ab}
25	0.5	15	92.14^{H}	-1.50^{c}	47.48^{ab}	91.81^{G}	4750^{ab}	30.77^{ab}
25	0.5	20	92.30^{G}	-1.57^{d}	47.04^{b}	91.91^{F}	47.07^{b}	30.31^{b}
25	1	5	92.44^{F}	-1.67^{f}	46.43^{c}	92.06^{D}	46.46^{c}	29.68^{c}
25	1	10	92.68^{CD}	-1.81^{ij}	45.36^{efg}	92.29^{zAB}	45.40^{efg}	28.57^{efg}
25	1	15	92.79^{AB}	-1.85^{jkl}	45.29^{efg}	92.34^{yzA}	45.33^{efg}	28.48^{fg}
25	1	20	92.84^{zA}	-1.88^{l}	44.79^{gh}	92.40^{w}	44.83^{gh}	27.98^{gh}
25	3	5	93.59^{v}	-2.36^{s}	42.85^{kl}	93.15^{r}	42.91^{kl}	25.91^{lmn}
25	3	10	93.94^{st}	-2.60^{tu}	41.25^{n}	93.61^{q}	41.34^{n}	24.27^{p}
25	3	15	94.00^{s}	-2.62^{u}	40.93^{n}	93.67^{p}	41.02^{n}	23.94^{p}
25	3	20	94.46^{r}	-2.74^{v}	39.10^{p}	94.00^{n}	39.19^{o}	22.05^{r}
25	5	5	94.76^{p}	-2.91^{w}	38.22^{q}	94.35^{m}	38.33^{p}	21.13^{s}
25	5	10	94.98^{n}	-3.00^{x}	37.57^{r}	94.57^{l}	37.69^{q}	20.45^{t}
25	5	15	95.17^{m}	-2.99^{x}	36.43^{s}	94.69^{k}	36.57^{r}	19.30^{u}
25	5	20	95.26^{j}	-3.15^{BC}	35.97^{st}	95.00^{j}	36.11^{rs}	18.83^{uv}
50	0.5	5	92.65^{CD}	-1.80^{l}	43.84^{ij}	92.35^{vz}	43.88^{ij}	27.09^{ij}
50	0.5	10	93.08^{y}	-1.93^{m}	42.82^{kl}	92.59^{v}	42.86^{kl}	26.00^{lmn}
50	0.5	15	92.32^{G}	-1.59^{de}	45.27^{efg}	92.01^{DE}	45.30^{efg}	28.57^{efg}
50	0.5	20	92.48^{F}	-1.63^{ef}	44.79^{gh}	92.07^{D}	42.86^{kl}	28.38^{fg}
50	1	5	92.80^{A}	-1.83^{ijk}	43.86^{ij}	92.39^{v}	43.90^{ij}	27.08^{ij}
50	1	10	92.49^{F}	-1.81^{ij}	43.64^{j}	92.38^{v}	43.67^{j}	26.92^{jk}
50	1	15	92.90^{z}	-1.87^{kl}	43.25^{jk}	92.48^{wx}	43.29^{jkl}	26.46^{jkl}
50	1	20	92.67^{CD}	-1.75^{gh}	44.45^{hi}	92.25^{BC}	44.49^{hi}	27.69^{hi}
50	3	5	94.84^{o}	-2.74^{v}	35.80^{st}	94.38^{m}	35.90^{rs}	18.74^{uv}
50	3	10	94.52^{r}	-2.57^{t}	37.48^{r}	93.92^{o}	37.57^{q}	20.46^{t}
50	3	15	93.89^{t}	-2.38^{s}	39.70^{o}	93.43^{q}	39.78^{o}	22.76^{q}
50	3	20	94.68^{q}	-2.74^{v}	36.23^{s}	94.32^{m}	36.33^{r}	19.18^{u}
50	5	5	95.49^{hi}	-2.89^{w}	32.92^{x}	95.02^{j}	33.05^{w}	15.79^{z}
50	5	10	94.85^{o}	-2.63^{u}	35.00^{uv}	94.30^{m}	35.10^{tu}	17.96^{wx}
50	5	15	95.95^{g}	-2.99^{x}	31.03^{z}	95.50^{f}	31.18^{y}	13.85^{B}
50	5	20	95.89^{g}	-3.02^{xy}	32.00^{y}	95.39^{g}	32.14^{x}	14.81^{A}
70	0.5	5	92.35^{G}	-1.57^{d}	46.21^{cd}	91.94^{EF}	46.23^{cd}	29.48^{cd}
70	0.5	10	$\mathbf{92.02^{l}}$	$\mathbf{-1.36^{a}}$	$\mathbf{47.74^{a}}$	$\mathbf{91.64^{H}}$	$\mathbf{47.76^{a}}$	$\mathbf{31.06^{a}}$
70	0.5	15	92.63^{DE}	-1.74^{g}	45.53^{ef}	92.19^{C}	45.57^{ef}	28.76^{ef}
70	0.5	20	92.58^{E}	-1.67^{f}	45.95^{cde}	92.08^{D}	45.98^{cde}	29.18^{cde}
70	1	5	93.11^{v}	-2.01^{n}	45.49^{efg}	92.54^{vw}	45.54^{ef}	28.62^{efg}
70	1	10	93.28^{x}	-2.10^{o}	43.25^{jk}	92.78^{u}	43.30^{jk}	26.38^{klm}
70	1	15	93.25^{x}	-2.20^{opq}	42.81^{kl}	92.94^{st}	42.87^{kl}	25.94^{lmn}
70	1	20	93.42^{w}	-2.22^{qr}	42.66^{kl}	92.98^{s}	42.72^{kl}	25.76^{mn}
70	3	5	95.24^{lm}	-3.00^{x}	35.38^{tu}	94.85^{j}	35.50^{st}	18.25^{vw}
70	3	10	95.40^{ijk}	-3.06^{yz}	35.01^{uv}	95.00^{j}	35.14^{tu}	17.86^{wx}
70	3	15	95.47^{hij}	-3.19^{C}	34.98^{uv}	95.21^{h}	35.13^{tu}	17.81^{wx}
70	3	20	95.42^{ijk}	-3.16^{C}	34.61^{vw}	95.22^{h}	34.75^{uv}	17.46^{xy}
70	5	5	96.06^{f}	-3.26^{D}	30.95^{z}	96.02^{e}	31.12^{y}	13.74^{B}
70	5	10	96.14^{e}	-3.27^{D}	30.68^{zA}	96.08^{de}	30.85^{yz}	13.46^{BC}
70	5	15	96.41^{c}	$\mathbf{-3.39^{F}}$	30.12^{AB}	$\mathbf{96.42^{a}}$	30.30^{zA}	12.87^{CD}
70	5	20	96.41^{d}	-3.26^{D}	30.02^{B}	96.19^{c}	30.20^{zA}	12.79^{D}
90	0.5	5	92.65^{CD}	-1.66^{f}	45.74^{def}	92.07^{D}	45.77^{def}	28.96^{def}
90	0.5	10	92.79^{AB}	-1.74^{gh}	45.18^{fg}	92.21^{BC}	29.99^{AB}	28.38^{fg}
90	0.5	15	92.80^{A}	-1.79^{hi}	45.29^{efg}	92.26^{ABC}	45.33^{efg}	28.49^{fg}
90	0.5	20	92.72^{BC}	-1.74^{g}	45.17^{fg}	92.20^{BC}	30.15^{A}	28.38^{fg}
90	1	5	93.25^{x}	-2.07^{o}	42.83^{kl}	92.76^{u}	42.88^{kl}	25.96^{lmn}
90	1	10	93.48^{w}	-2.16^{p}	42.73^{kl}	92.90^{t}	42.78^{kl}	25.82^{lmn}
90	1	15	93.57^{v}	-2.23^{qr}	42.54^{lm}	93.00^{s}	42.59^{lm}	25.61^{no}
90	1	20	93.72^{u}	-2.27^{r}	41.98^{m}	93.09^{r}	42.04^{m}	25.04^{o}
90	3	5	95.37^{k}	-2.98^{x}	34.68^{vw}	94.91^{j}	34.80^{uv}	17.54^{xy}
90	3	10	95.50^{h}	-3.02^{xy}	34.17^{w}	95.05^{j}	34.30^{v}	17.01^{y}
90	3	15	95.50^{h}	-3.11^{AB}	34.12^{w}	95.21^{h}	34.26^{v}	16.96^{y}
90	3	20	95.42^{hijk}	-3.07^{zA}	34.60^{vw}	95.08^{i}	34.73^{uv}	17.45^{xy}
90	5	5	$\mathbf{96.57^{a}}$	-3.24^{D}	$\mathbf{29.21^{C}}$	96.33^{b}	$\mathbf{29.39^{B}}$	$\mathbf{11.95^{E}}$
90	5	10	96.49^{b}	-3.25^{D}	29.81^{B}	96.23^{c}	45.21^{fg}	12.56^{D}
90	5	15	96.28^{d}	-3.34^{E}	30.17^{AB}	96.32^{b}	30.35^{zA}	12.93^{CD}
90	5	20	95.89^{g}	-3.23^{D}	29.80^{B}	96.15^{cd}	45.20^{fg}	12.81^{D}
Reference (Cod Lever Oil)			**97.97**	**-3.84**	**17.36**	**102.46**	**17.77**	**0**

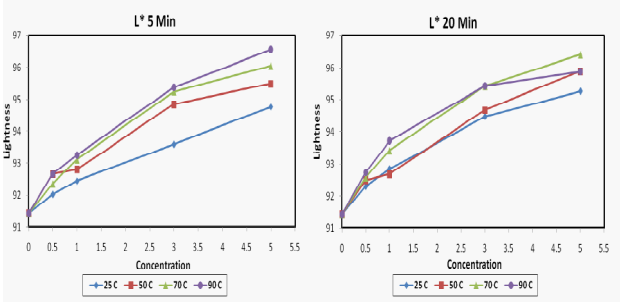

Figure 1. The L* value of Lemuru oil during refining at 5 minutes and 20 minutes process

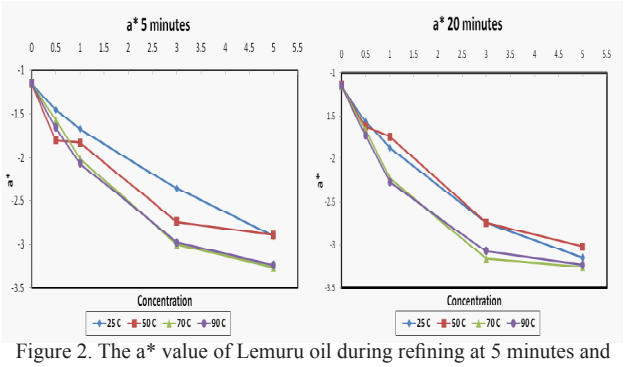

Figure 2. The a* value of Lemuru oil during refining at 5 minutes and 20 minutes process

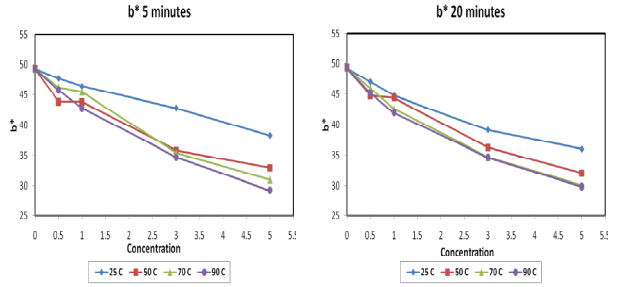

Figure 3. The b* value of Lemuru oil during refining at 5 minutes and 20 minutes process

color to the oil. As shown in Figure 2, the increasing of concentration and adsorption time result more green color at lemuru oil. At 5 minutes adsorption process, the activity of adsorbent at 70 ˚C and 90 ˚C had slight differences, but at 20 minutes process the adsorbent had higher activity while implemented at 70 ˚C. The more greenish color was produced as the reduction of red pigment occurred at adsorption process. At salmon oil, the reduction of carotenoid pigments such as astaxanthin and canthaxanthin during adsorption decreased a* value (redness), and increase –a* value (greenness) when using chitosan and activated earth as adsorbent (Huang and Sathivel, 2010).

At lemuru oil refining using Magnesol XL, the reduction b* value was the most significant result (Figure 3). The initial value of b* was 49.30, and after the adsorption process the b* value reached 29.21 (40.7% improvement) at 90 ˚C temperature, 5 % level of concentration and 5 minutes process. The increasing of Magnesol XL concentration, time and

temperature significantly affected the reduction of b* value (Figure 3). Significant reduction of yellow color, result the brighter yellow to colorless appearance at lemuru oil. It also decrease the intensity of lemuru oil color (lower C* value). For the comparison, the reference commercial cod oil has high L* value (97.97), low a* value (-3.84), low b* value (17.36) and high hue angle (102.46˚). Its color was observed as more greenish color due to its low value of b* (yellowness) than refined lemuru oil. Although the color measurement showed that all the experimental result had a hue angle higher than 90˚ (Table 1) and represent the greenish-yellow color, the total color difference (ΔE) calculation showed that the refined lemuru oil had very different color perception from Cod liver oil for consumer's point of view (ΔE > 1).

Conclusions

This study successfully showed that the refining process using Magnesol XL as adsorbent could enhance the color properties of lemuru oil. The highest L* value (96.57) and the lowest b* value (29.21) was achieved at 90 ˚C, 5% concentration for 5 min process. The lowest a* value (-3.39) and the highest hue angle (96.42˚) was achieved at 70 ˚C, 5% concentration for 15 min process. All the refined lemuru oils result had a hue angle higher than 90 ^{0}C which represented the greenish-yellow color. Although the color measurement showed that all the experimental result had very different color perception from Cod liver oil for consumer's point of view (ΔE > 1).

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