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Type of Adsorbent and Column Height in Adsorption Process of Used Cooking Oil

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Abstract. The purpose of this research was to find out the best adsorbent and column height that can adsorb color and soluble impurities substances in used cooking oil. This research was meant for knowledge development of refined cooking oil technology. The used of this research was giving out information on the recycling process of used cooking oil. Research design used 2x2 factorial pattern in randomized group design with 6 repetitions. The first factor is adsorbent type (J) that consist of activated carbon (J1) and Zeolit (J2). The second factor is column height (K) with variations of 15 cm (k1) and 20 cm (k2). Chemical analysis parameter are free fatty acid, water content and saponification value. Physical parameter measurement was done on color with Hunter Lab system analysis and viscosity using viscometer method. Chemical analysis result of preliminary research on used cooking oil showed water content of 1,9%, free fatty acid 1,58%, saponification value 130,79 mg KOH/g oil, viscosity 0,6 d Pas and color with L value of -27,60, a value 1,04 and b value 1,54. Result on main research showed that adsorbent type only gave effect on water content whereas column height and its interaction was not gave significant effect on water content. Interaction between adsorbent type (J) and column height (K) gave significant effect to free fatty acid, saponification value, viscosity and color for L, a and b value of recycled cooking oil.

Keywords: Adsorbents, Column Height, Adsorption Process, Used Cooking Oil

INTRODUCTION

Oil is one of calorie source that is very important for human. It contains useful component for the body and the most efficient source of calorie that is 9 calorie per gram. Oil not also used for frying but also use as rawa material for soap, candle, margarine, pomade, paint, lubricant, drugs and cosmetic [1].

Cooking oil is use in food process. The needs of cooking oil for household and industry is increasing, sometimes it availability is not meet with the consumen demand. This condition force the consument to reapetedly use cooking oil in cooking process and used cooking oil is very dangerous for health [2].

Cooking oil in food process act as heat transfer medium, add savory, and add nutrition subtance to the food product.

Frying process can be devided into two process, pan frying and deep frying. The most usual process in food processing is deep frying. In this process the food material submersed in hot oil (200-205^{0}C). High temperature process causes damaged chemical structure and also affected the odor and color of oil. Used cooking oil still can be reuse but it have to undergoes further process to reduce the odor and fix the color.

Adsorbent can reduce color and also capable on reducing pollutant such as soap, metal, fosfatide and sulfur [3]

In this research, activated carbon and zeolit was used as adsorbent. The benefit of using activated carbon as adsorbent is that it can be more effective to adsorb color than other adsorbent and also can adsorb some unwanted odor dan reduce the number of peroxide [1].

Zeolit as adsorbent has been frequently used for used cooking oil because it qualify as a good adsorbent also it is cheap and obtainable. The use of zeolit can improve the quality of used cooking oil because it can adsorb more free fatty acid [2].

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Oil quality is decrease because of hydrolisis process. It make the smoking point decrease, color change, and absorb more oil. Oil damage is occur in frying process, it can effected the quality and nutrition substance in food. Damaged oil because of oxidation and polymerization will generate unattractive appearance material, bad taste and also damaging the vitamin and essential fatty acid that contained in oil.

When heated to high temperature in the presence of air, oil undergoes chemical reaction such as oxidation, hydrolisis, and polymerization.

Oil that has been heated in high temperature, it double bond will be saturated. Prolong and repeated use can oxidized the double bond, formed peroxides and also breaking the unsaturated fatty acid. The vitamin that contained in cooking oil is also damaged, this condition makes nutritional function of cooking oil decrease and also give negative effect to the body [4].

It is necessary to carried out research on how to process used cooking oil to be reused for nonfood utilities. This research attempted to improve the quality of used cooking oil by finding the best type of adsorbent and column height that can best adsorb color and remove degradation product of oil.

RESEARCH MATERIAL AND METHOD

Material

Used cooking oil that has been use for 3 days, activated carbon and zeolit. For chemical analysis used KOH 0,5N, HCL 0,5N, Phenolphthalein, Alcohol 95% and KOH 0,1N.

Tools

This research used these following tools such as Chroma meter CR-200 Minolta, viscometer, Erlenmeyer, stir bar, analytic scale, water bath, biuret, cup, oven, desiccator, pipettes, and measuring cup.

Research method

Preliminary research

The characteristic of used cooking oil including saponification value, FFA, water content, color and viscosity were analyzed in detail using titration, gravimetric, Hunter measurement system and viscosimetri.

Main Research

In main research variation of adsorbent (activated carbon and zeolit) with height column (15 cm and 20 cm) was done to the refinery process of used cooking oil.

The treatment design used two factors, adsorbent (J) and height column (K) with 2 level. The research design used factorial pattern of 2x2 in randomized group design and repeated 6 times. Analyzed response was done on used cooking oil before and after the refinery process. This includes Free fatty acid determination using titration method [5], Saponification value using titration [5], water content using gravimetric [13], color using Hunter measurement system [6] and viscosity using viscometer method [7].

Research description

Used cooking oil that used in this research is cooking oil that come from the fried chicken seller and it has been used for 3 days. The oil is accommodated into jerry cans and brought to Food Technology lab for further analysis.

The oil then filtered by filtering paper to separate pollutant particle that is in the oil. The filtered oil, then being stored in a retort. After that the oil is put into refinery column that has been filled up by activated carbon and zeolit adsorbent. The height of each adsorbent is set at 15 cm and 20 cm.

The result of adsorption process then analyze it water content, free fatty acid, saponification value, color and its viscosity.

RESULT AND DISCUSSION

Preliminary Research

In this part of research the nature of used cooking oil before it going through adsorption process was carefully analyzed for its water content, free fatty acid, saponification value, viscosity and color.

The used cooking oil that is used in this research were repeatedly used by the trader. Characteristic of repeatedly used cooking oil are have high viscosity level, in room temperature the oil is in the form of semi-solid and with dark color. Analysis result of used cooking oil can be see in table 1.

TABLE1. Analysis Result of Used Cooking Oil

Variables	Value
Water content (%)	1.9000 ± 0.2874
FFA (%)	1.5800 ± 0.0728
Saponification value mg KOH/g Oil	130.7900 ± 0.0132
Viscosity d Pa.s	0.6000 ± 0.2017 d Pa.s
Color :	
L	27.6000 ± 0.0724
a	1.0400 ± 0.1618
b	1.5400 ± 0.1563

The data in table 1 showed that there is an increase of water content and free fatty acid percentages while the saponification value decrease compared to the standard value in SNI. The increasing water content in used cooking oil is caused by water from fried food. Many parts of the water evaporated but a few water still bounded by the oil. In high temperature frying, the structure of oil molecule was loosened and its separated from each other.

The data also showed that used cooking oil quality is very low compared to the SNI standard. The physical nature of the oil is also change, high viscosity percentages in room temperature and because of continuous use the color is also change to dark brown. The degradation substance resulted from frying process with high temperature condition like peroxide polymers, free fatty acid, metals and other pollutant, makes used cooking oil is not healthy for the body.

[11] , stated that cooking oil that has been used in high temperature frying and reused over and over will damaging the unsaturated fatty acid and makes discoloration, increased viscosity and free fatty acid in oil.

High value of fatty acid in used cooking oil causes decrement in smoking point and the color becomes darker.

Free fatty acid is produced from hydrolysis and oxidation, organism that attack fat. On first stage, it brake glyceride into free fatty acid and glycerol. The higher free fatty acid contain will speed up the rancidity process [3].

The higher value of saponification means that there are a lot of saturated fatty acid with short to medium chain molecule (have high molecular weight). From the data above shows that saponification value of used cooking oil is lower than SNI standard because glyceride hydrolysis process which formed short chain fatty acid that will evaporate in frying process. These will cause decrement on saponification value because only long chain fatty acid that remained in the oil.

Main Research

The purpose of main research was to find the effect of adsorbent and column height to the characteristics of used cooking oil that has been passed the adsorption column and the result was analyzed chemically and physically.

Water Content

The result of water content analysis on used cooking oil that has been passed through the adsorption column can be see in table 2.

TABLE 2. Statistical Analysis of Water Content

Type of Adsorbent	Average Value	5% Significance level
J2 (Zeolit)	0.9730	a
J1 (activated carbon)	1.2930	b

The significance differences from two type of adsorbent to oil water content causes by physical nature from the two. The size of activated carbon is smaller than zeolit so if a liquid being passed through activated carbon as adsorbent then there are lot more substance that can be adsorb in it. But in the case of water content, activated carbon cannot adsorb a lot of water compared to zeolit because it easy to saturated by water. The reason why zeolit has more capability to adsorb water because it has smaller size pores than activated carbon. Column height factor didn't give significance effect to water content.

Adsorption process of substance in a liquid is affected by type of adsorbent and also affected by liquid flow rate that gone through adsorption column. Faster liquid flow rate makes shorter contact time of adsorbent with liquid, this makes only a few of material in the fluid that can be adsorb [12].

The water content after adsorption process shows decrement compared water content before process but it still not comply with SNI standard.

Free Fatty Acid (FFA)

Statistical analysis showed that there are significant effect of type of adsorbent and column height and also their interactions to the FFA content.

J1k1 (Activated Carbon with 15 cm column height) and j1k2 (activated carbon and 20 cm column height) treatments resulted FFA content in used cooking oil ranged from 0.2% - 0.7%. In SNI, allowed value for FFA is maximal 0.3%. Treatment j1k2 with type of adsorbent activated carbon and 20 cm column height showed that contained FFA in oil is only 0.2809%. This value is in comply with SNI but it is not recommended to be used again because of healthy issue.

Saponification Value

Statistical analysis of saponification after adsorption process can be seen in the table below:

TABLE 3. The effect of type of adsorbent (J) and column height (K) to Saponification Value of Used Cooking Oil.

Type of Adsorbent	Column Height	
	K1 (15 cm)	K2 (20 cm)
J1 (activated carbon)	165.8000	194.5500
J2 (zeolit)	147.1200	163.9300

Sample J2k1 gave low value of saponification, this result is considered good because the lowest value means that there are fatty acid with long chain length in the used oil.

Viscosity

Viscosity considered to be one of the quality factor for cooking oil [3]. The statistical result for viscosity of used cooking oil after adsorption process showed that the higher adsorption column makes viscosity level increased. In this research the best sample for viscosity is j1k1 (activated carbon with 15 cm column height) with value of 0.543 d Pa.s.

Higher viscosity value means that the oil is severely damaged by high temperature frying and repeatedly used. [11] stated that cooking oil that has been through high temperature process and repeatedly used can damaged it contained unsaturated fatty acid and causing color change, increased viscosity and increased free fatty acid.

TABLE 4. Statistical Analysis Result of Viscosity

Type of Adsorbent	Column Height	
	k_1 (15 cm)	k_2 (20 cm)
j_1 (active carbon)	0.5430	0.6120
j_2 (zeolit)	0.5680	0.7000

Color

Color is very important visual consideration factor for food beside taste, texture, and nutrient content. It also can be indicator of freshness or ripeness and can be an indication to chemical changes on food like browning and caramelization [8].

Statistical analysis on color of used cooking oil after going through adsorption process can be seen in table 5

TABLE 5. Statistical Analysis Result of Color

Type of Adsorbent	Column Height	Chromatometer value		
		L	*A*	*B*
j1 activated carbon	k1 (15 cm)	28.8500 a	2.5583 a	5.6150 b
	k2 (20 cm)	31.0200 bc	4.0683 c	7.0100 c
j2 zeolit	k1 (15 cm)	29.9700 ab	2.3650 a	5.2000 a
	k2 (20 cm)	32.0100 c	3.4550 b	7.0450 c

From the table above, it showed that all the treatment gave significant effect across treatments for *L* values, because the effect of column height variations. The effect was be expected also from external factors like room temperature that can affected adsorption process, as the result the *L* values of each treatment will be different.

Like [9] stated that the amount of materials that can be adsorbed is affected by the concentration of substance in the absorbed materials, and also the temperature and pressure of research condition.

The effect of adsorbent to *a* value in j1k1 and j1k2 showed significant effect and column height treatment of j2k1 and j2k2 also gave significant effect to *a* value. So both variable gave similar effect to *a* value. Activated carbon with smaller in size and also have wider surface area with more pores than zeolit makes this type of adsorbent have better capability to adsorb pigment in used cooking oil.

The effect of adsorbent to *b* value in j1k1 and j1k2 gave significant result, and also for the effect of column height. This result beside of the two variable variation is also affected by pigment concentration or color density of used cooking oil. Distribution of pores size in an adsorbent will affected the amount of substance that can be adsorb from the oil and longer contact time of materials with adsorbent also give effect to the amount of adsorbed materials.

Color of oil is originated from natural color pigment like carotene, xanthophyll, chlorophyll, and anthocyanin. These pigments make oil color to be yellow, brownie yellow, green, and red. Color pigment that comes from degradation of natural color usually have darker color. This color transformation can be happened during storage and caused by too much exposure of high temperature during pressing process that makes part of the oil oxidized [3].

In this research, all treatment variations that has been done to the used cooking oil gave positive result to the color of used cooking oil. It color is significantly change from brown dark to yellow gold, this occur because the absorbance process especially the adsorbent can effectively adsorb dark color pigment in the oil.

[1] stated that activated carbon is more effective to adsorb color compare to other adsorbent, also it can adsorb odor partially and reduce the amount of peroxide.

CONCLUSION

In preliminary research we analyzed the characteristics of used cooking oil and it showed that all quality parameter is not comply with the national standart for cooking oil. Result of main research showed that type of adsorbent (J) only give significant effect to water content while column height and its interaction didn't give effect to water content, free fatty acid content, saponification value, and color *L, a* and *b*. Interactions between type of adsorbent (J) and column height (K) gave significant effect to free fatty acid content, saponification value, viscosity

and color *L*, *a* and *b*. The best resulted sample was j2k2 with 0.9730% water content, 0.3270% free fatty acid, 163.9300 mg KOH/g oil of saponification value, 0.7000 d Pa.s viscosity, *L* value of 32.01 (the appearance of oil is not to clear), *a* value of 3.4500 (the color of oil is reddish) and *b* value of 7.0450 (the color of oil is yellow). This sample considered the best because it quality parameter meet with quality requirement of cooking oil but its not recommended to used again because the oil is contained by free radical substance.

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