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Utilization of Wasted Cooking Oil and Essential Oil of Sweet Orange Peel (*Citrus sinensis*) as Aromatherapy Candles

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ABSTRACT. Utilizations of waste cooking oil can be projected to be candles. Sweet orange (*Citrus sinensis*) peel, considering a large amount of this abandoned waste, also can be utilized as essential oil. This research was conducted to examine the production of aromatherapy candles by purifying the wasted cooking oil and adding the sweet orange peel essential oil. Steam distillation method was used to extract essential oils by determining the effect of raw material conditions on the yield obtained. The essential oils obtained from fresh peel had 1.87% yield with 94.37% limonene, while dry ones had 2.16% yield with 94.67% limonene by GC-MS analysis. Adsorption method by activated carbon was carried out to purify the wasted cooking oil as candle materials, varied by 7%, 10%, and 13% mass of activated carbon. The addition of the highest mass of activated carbon gave the lowest absorbance and indicated that the purified oil was the brightest. Utilization of refined wasted oil was mixed with stearin and sweet orange peel essential oil of 2%, 4%, and 6% by weight as aromatherapy candle product. Characteristics of candle were investigated by analyzing the melting point, burning time, organoleptic, and preference test for respondents and resulted that all characters meet Indonesian National Standard. The purification of wasted cooking oil varied by activated carbon mass, which influenced the color of the candles. The addition of essential oils influenced the smell, melting point, and burning time of the candle; the essential oil addition lowers the melting point and increases the burning time.

1. INTRODUCTION

Palm cooking oil is one of the staple household needs of Indonesian families. Annual consumption of palm cooking oil in Indonesia reaches 2,730 and 8,042 thousand tons at 2021 and 2022, respectively, with a growth rate 194.61% based on data obtained from the Indonesian Statistics of Food Consumption 2022 (Pusat Data dan Sistem Informasi Pertanian, 2022). Cooking oil that has been used repeatedly is known as wasted cooking oil. Heating cooking oil at high temperatures could remove the vitamins and form unhealthy fatty acids as a result of the hydrolysis reaction (Choe & Min, 2007; Ilyas, 2018). The hydrolysis reaction was caused by contact between palm cooking oil and water. Palm cooking oil splits into free fatty acids and glycerol and causes damage to the oil. In addition, an oxidation reaction occurred due to contact between oxygen from the surrounding air and palm cooking oil during frying caused in production of peroxide, rancid odor, and a dark brownish color in the oil (Nduka et al., 2021; XF, Leong et al., 2012). Decreasing cooking oil quality reduces the foods' nutritional value, thus interfering with health (Mishra et al., 2023). Careless disposal of leftover cooking oil also damages the balance of the ecosystem in the environment: water pollution due to the covering of the water surface from sunlight and soil pollution due to blockage of soil pores. Utilization of used cooking oil can be done by taking advantage of high free fatty acid content in wasted cooking oil as a raw material for making biodiesel, solid or liquid soap, surfactant, and candle (Awogbemi et al., 2021; Baena et al., 2022; Permadani et al., 2018; Ridlwan et al., 2023).

Originally, candle was used as a source of heating and lighting. The first raw materials for candle-making were from animals (beeswax and tallow) and plants (olive and castor oil). Paraffin was also used as candle making from petroleum source. Paraffin is a mixture of solid hydrocarbon as a byproduct of oil refinery process. However, candle-based paraffin was reported to produce harmful volatile substance while burning such as benzene and toluene (Massoudi & Hamidi, 2017). Benzene has found to be linked to blood cancer and leukemia, while toluene linked to liver, kidneys, and nervous system failure. People usually burn candles indoors, which causes people to inhale the residual gas from the combustion for a longer period.

Currently, candles are not only used as those functions. Candle innovations emerged with the addition of fragrance from essential oils, commonly known as aromatherapy candles. The fragrances have a relaxing effect, relieve stress, and overcome insomnia (Gnatta et al., 2016; Lee et al., 2022). This increases the urgency of changing material candles to be safer for humans and the environment. Natural waxes such as fatty acids and stearins can substitute the harm materials, which also had properties as phase change materials like paraffin wax (Eštoková & Kapalo, 2022). One of the famous fragrances of aromatherapy candles is orange essential oil. Sweet orange (*Citrus sinensis*) is a local fruit and easy to find, especially in Surakarta, Indonesia. Based on data from the Central Statistics Agency for 2020, orange productivity in Indonesia was 2,239,032 tons (Badan Pusat Statistik, 2023). Sweet oranges are usually used by squeezing the juice for direct consumption. This causes orange peel waste as organic waste that can decompose in the environment considering that sweet orange consists of 35-50% fruit juice, 10-20% fiber, and up to 35-45% peel (Satari & Karimi, 2018; Sharma et al., 2017). Thus, if it left alone in large quantities it can cause a bad smell and become an environmental problem. Essential oils in orange peel generally contain 94% limonene, 2% myrcene, 0.5% linalool, 0.5% octanal, 0.4% decanal, 0.1% citronellal, 0.1% neral, 0.1% geranial, valensene 0.05%, β-synensial 0.02%, and α-synensial 0.01% which limonene is one of the dominant compounds which has natural insecticide properties (Ferrer et al., 2022; González-Mas et al., 2019; Mursiti et al., 2019; Sharma et al., 2017). This fresh and citrusy aroma provide fragrances with therapeutic effects such as calming, stress relief, refreshing, and arousing enthusiasm.

Adding essential oil from orange peel can provide added value to used cooking oil-based candles in the form of a distinctive, attractive, and relaxing aroma, natural insecticide properties, and be a solution to the abundance of orange peel waste in the environment. This study aims to utilize wasted cooking oil as basic material of candle making and sweet orange peel as aromatherapy essential oil for candles. The purification of wasted cooking oil was conducted by varying the mass ratio of activated carbon to wasted cooking oil, and the extraction of orange peel was conducted by varying the conditions of the orange peels.

2. MATERIALS AND METHODS

Orange (*Citrus sinensis*) peels as essential oil raw material was obtained from a local seller in Surakarta, Central Java, Indonesia. Pretreatment was conducted to remove the fruit pulp and fiber left from the orange peels, then washed them thoroughly. Wasted cooking oil with normal used was collected from local neighborhood in Surakarta, Central Java, Indonesia. The wasted cooking oil was then filtered first to remove impurities in the form of leftovers from frying.

2.1 Extraction of sweet orange peel essential oil

The extraction process was carried out with 2 variations of material conditions: fresh and dry sweet orange peels. Dried sweet orange peels were obtained by drying at 50°C for 6 hours. Both dry and fresh orange peels were then crushed into slurry and 100 grams of each process was measured. Distillation was started by adding 500 mL of water into a three-neck flask and boiled at 100°C. The sweet orange peel was put into the column and the distillation was carried out for 3 hours. The essential oil produced was then weighed on a pycnometer.

2.2 Purification of wasted cooking oil

Wasted cooking oil was purified using activated carbon adsorbent from bamboo with a size of -80 +100 mesh. The purification process was carried out by varying the mass of activated carbon by 3.5; 5.5; and 7.5 grams for every 50 grams of oil and performed by 340 rpm continuous stirring at a temperature 100-110°C for 60 minutes. The solution was then filtered 3 times.

2.3 Production of aromatherapy candles

Purified wasted cooking oil was heated with stearin in ratio 1:1 and maintained at 60-70°C with a stirring speed of 340 rpm for 60 minutes. After 1 hour, the temperature was lowered to 40-50°C, and the essential oil was added with variations of 2%, 4%, and 6% by weight of the candle. After homogenization, the liquid aromatherapy candle was transferred into a molded glass with a candle wick in the middle. Liquid aromatherapy candles were left overnight until they hardened into solids.

2.4 Analytical Method

Compound analysis in essential oils was conducted using GC-MS (Gas Chromatography-Mass Spectrometry), while the density of sweet orange peel essential oil was determined using a pycnometer. Analysis of used cooking oil was carried out using a UV VIS spectrophotometer with a 475 nm wavelength to determine the absorbance value of the oil before and after purification. Analysis of aromatherapy candle products was carried out by testing the length of burning time, melting point, candle flame, organoleptic, and respondents' preferences to determine the quality of aromatherapy candles.

3. RESULTS AND DISCUSSION

3.1. Extraction of orange peel waste

Fresh and dried sweet orange peels were used as raw materials for distilling essential oils using steam. These two conditions were analyzed based on the storage conditions consideration. Distillation of fresh sweet orange peels produced 1.8654 grams essential oil with a yield of 1.87%, while distillation of dried one produced 2.1627 grams essential oils with a yield of 2.16%. GC-MS (Gas Chromatography-Mass Spectrometry) analysis was performed to determine the compounds present in sweet orange peel essential oil. GC-MS result as presented in Figure 1, shows that limonene was the highest percentage compounds presented in both variations.

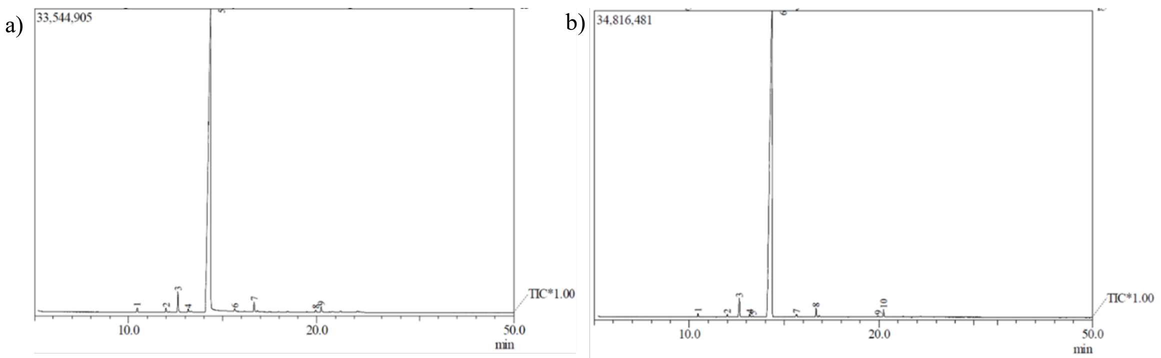

Figure 1. GC-MS results of a) fresh and b) dried sweet orange peel essential oil

From the figure 1, fresh sweet orange peel essential oil had the largest composition of 94.37% limonene (at retention time 14.367) and 2.17% myrcene (at retention time 12.633), while the dried one had 94.67% limonene and 2.0% myrcene. These results aligned with many previous studies where limonene and myrcene were the dominant compounds in orange peel essential oil, around at 96.69% (limonene) and 1.30% (myrcene) (Di Rauso Simeone et al., 2020; Ferrer et al., 2022; González-Mas et al., 2019; Sharma et al., 2017). It can be concluded that drying pretreatment on sweet orange peel did not show a significant difference. However, from a storage and process consideration, dried sweet orange peels were more recommended than fresh ones. The water content of fresh orange peel was 75 – 90%, and it causes the material to be easily damaged and the shelf life was very low (de la Torre et al., 2019; M'hiri et al., 2015). Drying, the traditional food preservation techniques, can ensure a long shelf life of biological materials by minimizing the growth of microorganisms and enzyme activity by reducing the water content of materials (Farahmandfar et al., 2020).

3.2. Purification for wasted cooking oil

Wasted cooking oil was purified by an adsorption process. The process was conducted by three variations of activated carbon mass fraction to know the best performance in refining wasted cooking oil, 7%, 10%, and 13%

mass of activated carbon. The refined wasted cooking oil was then measured for its absorbance using a UV-Vis spectrophotometer at a wavelength of 470 nm. The results of absorbance measurements can be seen in Table 1.

Table 1. Absorbance Measurement Result of Wasted Cooking Oil Purification

% Mass of Activated Carbon	Average Absorbance Value
7%	0.914
10%	0.867
13%	0.816

Based on Table 1, the wasted cooking oil with the addition of 7% mass of activated carbon gave a highest value of 0.914, while the addition of 13% mass of activated carbon gave the lowest value of 0.816. The absorbance value of wasted cooking oil that did not undergo a refining process was 1.064. A high absorbance value indicated that more light was absorbed and less light was transmitted by the dark and cloudy oil. Thus, the mass amount of activated carbon added to the refining process affected the absorbance value, the more activated carbon added, the brighter the color of the oil will be. Hence, greater quantity of activated carbon used requires a further refining process in separating the oil from the remaining active carbon used.

3.3. Analysis of Aromatherapy Candles

Purified wasted cooking oil and palm stearin was mixed by the same mass ratio to form 20 grams of candle mixture. Three various % mass of orange peel essential oils was then added for making aromatherapy candles. Purified wasted cooking oil used as raw material for making candles since it had fatty acids as a basic ingredient for making candles. Palm stearin is the solid fraction obtained from palm oil dry fractionation which has high melting point 46.7°C (Nusantoro, 2009). Palm stearin played a role as natural material for making candle instead of the petroleum based. The formula of aromatherapy candles based on the addition of activated carbon in purification process with A, B, and C for 7%, 10%, and 13% mass of activated carbon respectively, and were then classified for each of them by the addition of orange peel essential oil into 0, 1, 2, 3 for 0%, 2%, 4% and 6% mass of orange peel essential oil. The formula for each variation of aromatherapy candles is presented in Table 3. Aromatherapy candle products made by 12 formulas are displayed as Figure 1.

Table 2. Aromatherapy Candles Formulas

Formula	Activated Carbon (% mass)	Orange Peel Essential Oil (% w/w)
A0	7	0
A1	7	2
A2	7	4
A3	7	6
B0	10	0
B1	10	2
B2	10	4
B3	10	6
C0	13	0
C1	13	2
C2	13	4
C3	13	6

The products of the aromatherapy candle formulation were then tested for organoleptic, flame test, melting point, burning time, and respondents' preferences to determine the quality of the aromatherapy candles produced. The parameters used are the candle's shape, color, and aroma. This organoleptic test will also be used as a parameter of consumer acceptance or preference for aromatherapy candles. The results show that all the aromatherapy candles had solid shape, hard texture, and do not crack. Thus, the products were in accordance with Indonesian National Standard (SNI) number 0386-1989-A/SII 0348-1980.

Figure 2. Aromatherapy Candles

The candles showed three types of colour based on the purification process and were classified by the addition of activated carbon as #F8E3AD, #FDE8AF, and #FEEAB6, as presented in Figure 2. The decrease in the absorbance value of purified wasted cooking oil after purifying process indicated that the color of the wasted cooking oil was getting lighter. Aromatherapy candle products with formula C have the color code #FEEAB6 which tends to be the brightest compared to the others. The flame test showed that all aromatherapy candle formulas produced a yellow flame, did not cause sparks and smoke, thus these candles were in accordance with SNI 0386-1989-A/SII 0348-1980. On the other hand, the variation of purification wasted oil and the addition of essential oil were not influence this color characteristic of the candle.

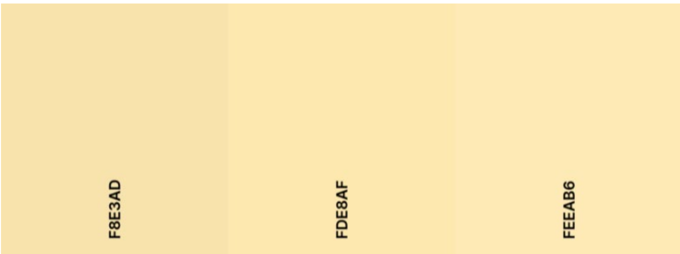

Figure 3. The difference of color and code of aromatherapy candles

The aroma test was carried out in a 9.6 m x 8.1 m classroom. The smell of orange essential oil was noticed strongest in candle with the biggest addition of essential oil (6% mass) among all candles after being burnt. In contrary, the smell of orange essential oil was not detected when the candle was not lit. This because the essential oils only evaporated as the candle burned (Ahmad et al., 2023; Danh et al., 2020; Muhammad et al., 2022). The addition of more essential oils gave a stronger fragrance.

3.4. Consumers Sensory Perception Analysis

These data were further analyzed by consumers sensory perception among respondents to evaluate the shape, color, and aroma of aromatherapy candles according to oil purification and essential oil addition in the same classroom area. The rating scale used was 1 (strongly dislike) to 5 (strongly like). The shape and color of the aromatherapy candle before and after lit had the same value in the range of 4 to 5 which means that all respondents like and totally like the shape and color of all candles. This result was in accordance by conclusion about color characteristic of the candle before.

The result of the aroma test of the candles after lit by consumers sensory perception analysis was presented in Figure 4. From the graph below, there are three kinds of candle, A0, B0, and C0 which had the worst value by respondents since there were no essential oil added. By the addition of essential oil to the candles, the quantity of respondents' perception was increase to value of 4 and 5 which means like and strongly like, respectively. This phenomenon occurred by B2 and C2 which had 4% of essential oil, and B3 and C3 which had 6% or the highest percentage of essential oil. These results lead to a conclusion that the more the addition of orange peel essential oil, the stronger the aroma produced. Candles without the addition of essential oils get low scores because the aroma of the candle only came from the evaporated essential oil as candle burning.

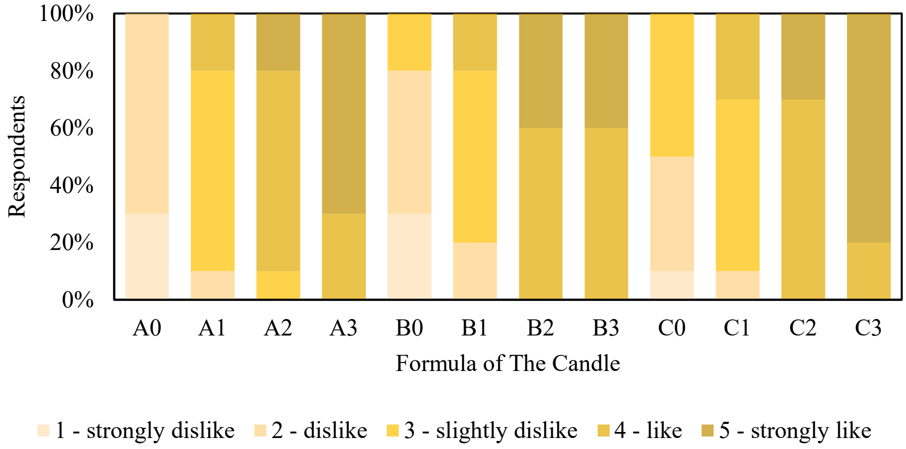

Figure 4. The result of aroma test by consumers sensory perception analysis

3.5. Melting Point and Burning Time Analysis

The results of melting point and burning time analysis can be seen in Figure 5. It shows that the melting point of all candle complied with SNI 0386-1989-A/SII 0348-1980 standard in the range of 50°C – 58°C. Candles with no essential oils had the highest value among the others. It can be concluded that the addition of essential oils lowering the melting point of the candle. Solid-liquid transition temperature of natural based candle reported lower than paraffin-based wax which palm stearin wax and paraffin wax had melting point at 50°C and 60°C, respectively (Eštoková & Kapalo, 2022; Nusantoro, 2009). In addition, this mixture of wasted cooking oil (fatty acid) and palm stearin was in the range of melting point of palm stearin and paraffin wax.

The burning time was the time interval that shows the resistance of the candle while burning. Candles without essential oils addition produced the longest burning time, while candles with essential oils addition experienced a decrease in burning time. The more essential oils were added, the burning time would also decrease. The melting point of the candle related to its burning time; a high melting point of the candle had a long the burning time. The essential oil added vaporize along with the burning candle, as it escalates the rate of evaporation (Ahmad et al., 2023; Danh et al., 2020). This event leads to increase the burning rate and impacts the durability of the candle such as shorter burning time and lower melting point.

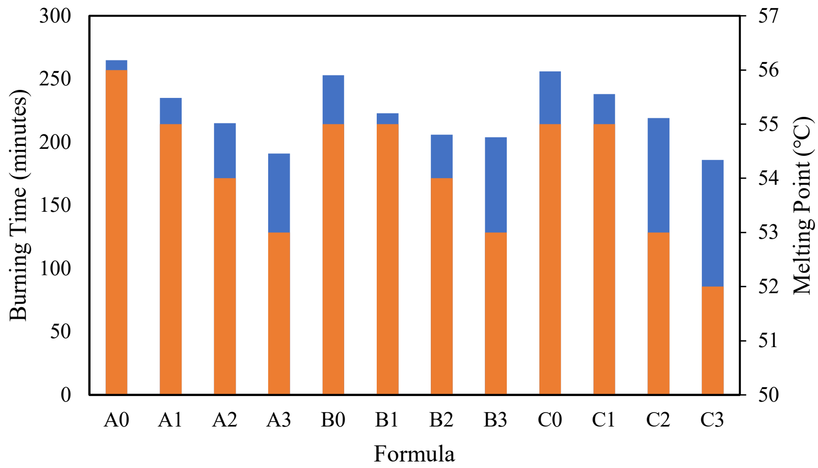

Figure 5. Burning Time and Melting Pont Results of each formula candles

4. CONCLUSION

Wasted cooking oil can be utilized as raw material for candles by purification process using bamboo activated carbon as an adsorbent. The optimum purification process was obtained by the highest percent mass (13%) of activated carbon which gave the brightest color of the oil. Essential oil can also be generated by sweet orange peel with the highest yield at 2.16% containing 94.67% limonene content at dry material condition. The addition of orange peel essential oil increased the value of wasted cooking oil-based candle. The utilization of waste cooking oil and orange peels could be stated as a problem solving to the environment and an added value to waste.

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