Production of Aromatherapy Candles from Palm Kernel Oil(PKO)

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Abstract
Palm Kernel Oil (PKO) is a by-product of the palm oil industry that has the potential to be used as an alternative raw material for making aromatherapy candles. This research aims to make aromatherapy candles made from PKO and evaluate the physical characteristics and quality of the products produced. The research method used a variation of PKO concentration (5 ml, 10 ml, 15 ml) combined with stearic acid as a hardening agent (30 gr, 40 gr, 50 gr). The manufacturing process includes mixing PKO with stearic acid at a certain temperature, adding essential oil as fragrance, and printing using wax wicks. Product evaluation is carried out through testing of physical characteristics including shape, color, aroma intensity, flame stability, and burn durability. The results showed that the best formulation was obtained in a combination of 10 ml PKO with 40 gr of stearic acid. The aromatherapy candles produced have optimal characteristics in the form of a smooth and stable solid form, homogeneous and attractive colors, a strong and long-lasting scent both before and after burning, a stable flame without producing black smoke, and an optimal burning time. Overall, aromatherapy candles from PKO can meet physical, aesthetic, and functional aspects so that they are suitable as an alternative value-added product from Palm Kernel Oil waste.

1. Introduction

The palm oil industry is one of the main economic pillars in Indonesia, with Kalimantan being one of the largest palm oil producing regions in the world. So far, crude palm oil (CPO) has been the main focus of global production and marketing. However, it should be noted that the palm oil processing process also produces an abundant by-product, namely Palm Kernel Oil (PKO) or palm kernel oil. PKO is obtained through palm kernel pressing and has great potential that has not been utilized optimally (Syahputra & Handayani, 2023). Although PKO has high economic value and nutritional content, its use in Kalimantan is still very limited, generally only absorbed in the food industry (such as margarine and shortening) and oleochemicals (such as soaps and cosmetics) on a large scale. As a result, PKO is often simply stored, sold as raw materials at low prices, or even wasted. Data shows that in one of the large factories (PT X), PKO production can reach about 108,000 tons per year out of a total of 240,000 tons of kernels processed. This volume shows that PKO is a very abundant by-product, but the lack of diversification of utilization causes most PKO to be considered as secondary waste with a lower selling value than CPO (Wulandari & Kusuma, 2023). The accumulation of unused PKO has the potential to cause environmental problems and economic losses for companies (Siregar et al., 2022). Therefore, efforts are needed to diversify the use of PKO to increase added value and minimize environmental impact.

Meanwhile, on the other hand, there has been a significant increase in people's needs for environmentally friendly products with health value, one of which is aromatherapy candles. Aromatherapy candles not only serve as decorations, but also provide a relaxing and therapeutic effect, which is urgently needed by people who face high levels of saturation and stress due to the demands of daily activities (Sukmawati et al., 2024). In fact, a study in Surabaya showed that 91.78% of respondents of productive age felt the effectiveness of aromatherapy in reducing mild stress. The need for more natural and sustainable wax raw materials opens up great opportunities to utilize PKO, given that the high content of lauric acid (40-52%) and stearic acid (1-3%) in PKO provides physical properties suitable for wax manufacturing, such as a solid texture and good melting point (Setiyawan et al., 2023).

Aromatherapy candles themselves are defined as candles that contain fragrances (essential oils) and are used not only as lighting, but also for the purpose of refreshing, relaxing, and relieving headaches. The use of aromatherapy candles is gaining popularity because it is considered energy-efficient and has minimal side effects, making it a simple solution to relieve physical and mental stress and fatigue (Dewi & Permatasari, 2021). The function of candles has shifted from being just a lighting aid to an element of decoration and air freshener. Candle air fresheners have advantages in terms of practicality, ease of use, and storage and packaging. Different types of aromatherapy, such as essential oils and candles, have emerged over time, and each has specific properties, such as the scent of lavender which is believed to reduce stress and difficulty sleeping. Thus, aromatherapy candles provide calm and comfort to their users, making them an effective non-pharmacological therapy for reducing sleep disturbances.

The basic ingredient of conventional wax, Paraffin wax (paraffin wax), which is made from petroleum, composed of alkan hydrocarbon compounds with the formula CnH2n+2 (where the n value ranges from 19 to 36), has potential health risks because it is composed of volatile organic compounds that have the potential to poison the body and increase the risk of respiratory distress and cancer if inhaled in the long term (Wijayanti & Adiwijaya, 2020). Therefore, PKO, or palm kernel oil, which is the second leading product after CPO, is produced from the process of pressing palm kernels after being separated from oil palm fruits, where in Kalimantan it is often only absorbed limited in the food and oleochemical industries, offering a better alternative. The fatty acid content contained in Palm Kernel Oil is: lauric acid 40-52%, myrcystic acid 14-18%, oleic acid 11-19%, palmitic acid 7-9%, caphatic acid 3-7%, caprylic acid 3-5%, stearic acid 1-3%, and linoleic acid 2%. In particular, the stearic acid content in PKO (Palm Kernel Oil) of 1-3% can be used as an ingredient in making wax (Setiyawan et al., 2023). In addition, the advantage of PKO for candles lies in the high content of Lauric Acid (40-52%). Lauric acid has important benefits in the manufacture of aromatherapy candles, namely: Improving Candle Stability, Accelerating Scent Release, Providing a Soft Texture, and Clean Burring. On the other hand, Stearic acid or stearic acid, which is also a by-product of palm oil processing plants and contains saturated triglycerides, in the form of a shiny hard solid, resembling waxy fat, with a melting point of 44–56 °C, has a crucial function in the production of wax, namely: Used to harden and strengthen wax, Has an effect on the melting point of wax, and as an Increase in Violence.

In this study, stearic acid acts as a hardening material to compensate for the properties of PKO which tend to be soft due to its high lauric acid content. As a functional value enhancer, essential oils, which are volatile oils from plants and serve as the base of fragrances used in cosmetics, perfumes, and aromatherapy, will be used. Essential oils have various therapeutic properties, such as reducing stress, relaxing the body, overcoming insomnia, reducing anxiety, and improving immunity and breathing. Some common plants that are used include lavender, peppermint, rose, and chamomile. In this study, essential oils with red rose and lavender scents were used to provide the expected relaxation effect.

Given the serious challenges in the form of the accumulation of Palm Kernel Oil (PKO) as a by-product of the palm oil industry that has not been optimally utilized in Kalimantan and the market opportunities for aromatherapy candles, this research finally aims to explore and develop innovative formulations to achieve optimal conditions in the manufacture of aromatherapy candles made from PKO. This strategic move is not only designed to transform PKO, from what was originally considered a low-cost secondary waste to a highly

economical commodity that can be diversified, but also to effectively provide a more natural, high-quality, sustainable alternative to wax products, as well as support modern consumers' needs for environmentally friendly relaxation solutions.

2. Research Methods

This study uses a laboratory experimental method (Laboratory Experimental Study). The design of this study aims to test the effect of variations in the composition of raw materials on the physical and functional characteristics of the aromatherapy candles produced.

Research Variables

Fixed Variable : Raw Material (Paraffin 50gr, Dye 1g and Essential Oil 10ml), Temperature 1500C

Free Variables: PKO 5ml, 10ml, 15ml and Stearic acid 30gr, 40gr, 50gr

Tools and Materials

The tools used in this study are Beaker glass, Spatula, Thermometer, Hot plate, Digital Scale, Petri Dish, Wax Mold, Wax Wick, Erlenmeyer, Measuring Cup. The materials used in this study are PKO, Paraffin, Stearicacid, Essential Oil, Dyes.

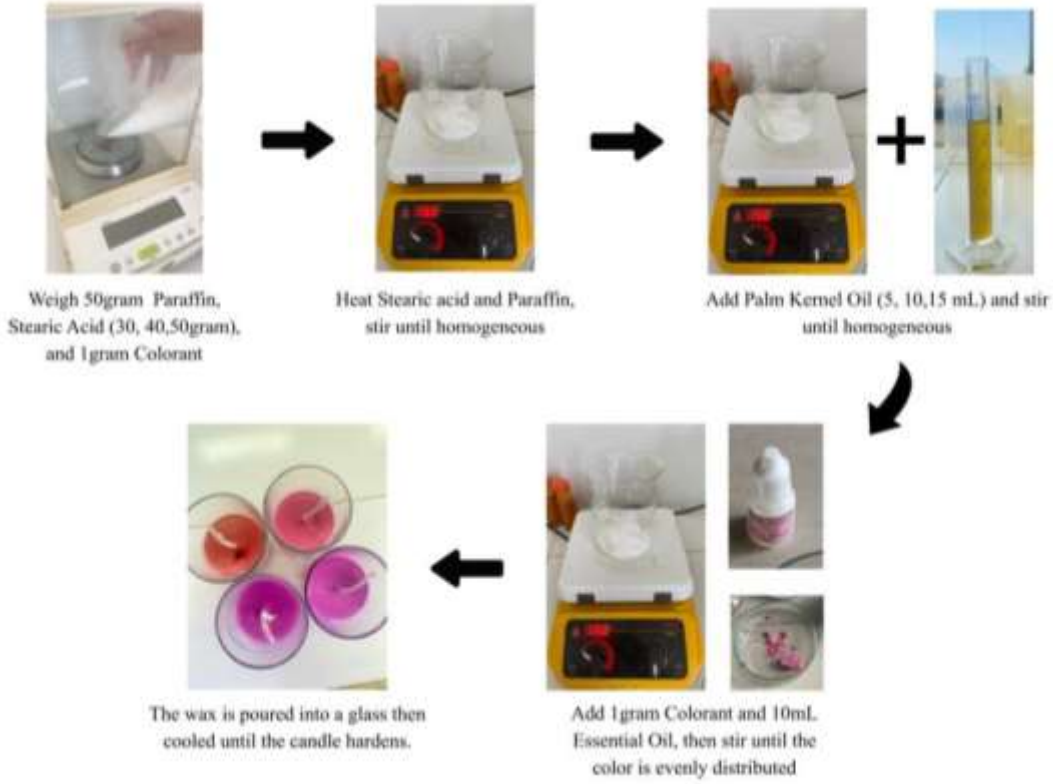

Fig 1. series of processes

Aromatherapy Candle Making Procedure

The process of making candles begins with accurate preparation and weighing of materials. A total of 50 grams of Paraffin was weighed, followed by Stearic Acid weighing which was varied in three concentrations, namely 30, 40, and 50 grams. In addition, PKO was measured separately with varying volumes, namely 5, 10, and 15 milliliters, as well as 1 gram of dye and 10 ml of fragrance.

After weighing, Paraffin and Stearic Acid are put into a 500 ml beaker glass and heated using a hot plate. The heating temperature is set high, reaching 150°C. This mixture is stirred using a spatula for 15 minutes until both ingredients are completely melted.

Next, PKO (as much as 5, 10, or 15 ml) is added to the Paraffin and Stearic Acid melt. After that, dyes (1 gram) and fragrance (10 ml) are added to the mixture. The melt temperature is kept constant (150°C) for 30 minutes while constantly stirring to ensure all components are homogeneously mixed.

Finally, the wax melt is poured into the prepared mold, then the wax wick is added. The wax is allowed to cool at room temperature for 80 minutes until it is perfectly hardened and ready for testing.

3. Results and Discussion

This study was conducted to evaluate the formulation of aromatherapy candles using various basic ingredients, namely Palm Kernel Oil (PKO), Crude Palm Oil (CPO), paraffin, and a mixture of PKO and CPO. The additional ingredients used are paraffin 50 g as the main base, as well as stearic acid with concentration variations of 30 g, 40 g, and 50 g as wax hardeners and stabilizers. In addition, the variation in the amount of PKO and CPO added is 5 ml, 10 ml, and 15 ml.

Fig 2.Comparison of sample results

Table 1. Experimental Sample Results

Yes	Sample	Shape	Color	Aroma	Flame	Baking Time
1	PKO:5 ml, SA:30gr	Less dense, slightly brittle	A bit pale	Less sharp	Small flames, sometimes unstable	Quickly runs out
2	PKO:5 ml, SA:40gr	Solid, but a bit hard.	Slightly sunny	enough	The fire is stable but small	keep
3	PKO:5 ml, SA:50gr	Very loud	Dull	Very weak	stable	old
4	PKO:10ml, SA:30gr	Compact, but a bit oily.	Faded	sharp	Stable but a bit large	Quickly runs out
5	PKO:10ml, SA:40gr	Dense, smooth, stable	Evenly and unevenly integrated	Strong and durable	Stable non-smoking	Optimal (not running out quickly, not too long)
6	PKO:10ml, SA:50gr	Very dense, a bit hard	Uneven and dull	Decreased	stable	It's been a long time coming, but the smell is not good.

Yes	Sample	Shape	Color	Aroma	Flame	Baking Time
7	PKO:15ml, SA:30gr	Soft, melt-easy	Faded and shiny	Very powerful	Large, sometimes smoky	Quickly runs out
8	PKO:15ml, SA:40gr	Compact, but a bit oily.	Slightly faded and shiny	Quite powerful	stable	keep
9	PKO:15ml, SA:50gr	Solid and hard	A bit dull	weak	stable	Old

Table 2. Experimental Result Score

PKO (ml)	HIS (gr)	Shape	Color	Aroma	Flame	Baking Time
5 ml	30 gr	2	2	1	1	1
	40 gr	1	3	2	1	1
	50 gr	1	2	1	3	1
10 ml	30 gr	1	1	3	2	2
	40 gr	5	5	3	4	3
	50 gr	2	2	1	3	1
15 ml	30 gr	1	2	3	2	2
	40 gr	2	1	2	3	3
	50 gr	1	1	1	3	1

Ket: Shape	**Ket: Color**	**Ket: Aroma**	**Ket: Flame**	**Ket:Long Burning Time**
				1=Expired
1=Very Bad	1=Very Uneven	1=Not sharp	1=Small	2=Run Out Quickly
2=Not good	2=Uneven	2=Medium	2=Large	3=Optimal
3=Medium	3=Medium	3=Sharp	3=Medium	
4=Good	4=Equal		4=Optimal	
5=Very Good	5=Very Evenly Distributed			

Based on the results of the pre-research that has been carried out, it was found that the best aromatherapy candle formulation is found in a combination of PKO 5 ml, 10 ml, and 15 ml with paraffin 50 g and stearic acid 30 g, 40 g, and 50 g. Therefore, the formulation was chosen for use in further research, with the aim of in-depth evaluation of the physical characteristics, combustion quality, aroma stability, and conformity with the SNI standards of aromatherapy candles.

Fig 3. Best Sample Result

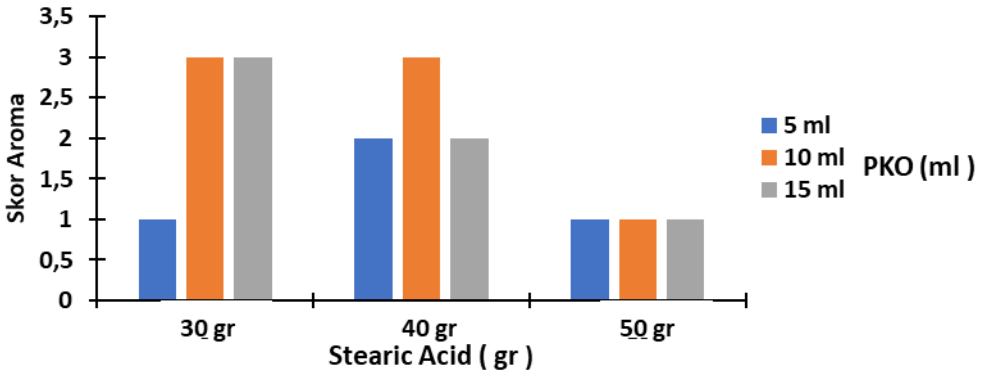

Fig 4. Aroma Test

In the aroma test with 5 mL PKO treatment, the ratio of stearic acid (30 grams or 40 grams) became very dominant. This makes the wax dough very thick and dense when melted. This very high viscosity inhibits the movement and dispersion of perfume molecules. Perfumes cannot spread evenly and tend to clump or get trapped in the dense matrix of the wax, resulting in a less strong scent. In candles with 5 mL of PKO, because the perfume is not evenly distributed, the release of the scent is unstable. Some parts may give off a slight scent, while others may not at all, causing the overall scent to feel unsharp or less intense.

In treatment with 10 ml and 15 ml PKO, the PKO ratio becomes more balanced or higher. This makes the wax dough have an ideal viscosity, not too thick or too liquid. A higher concentration of PKO allows the perfume to dissolve perfectly and disperse homogeneously throughout the dough. In candles with 10 ml and 15 ml of PKO, since the perfume is already evenly dispersed throughout the dough, the concentration of the perfume in the melting pool becomes uniform. This ensures that when the candle burns, the fragrance oil molecules evaporate constantly and evenly, resulting in a sharp and consistent scent during burning.

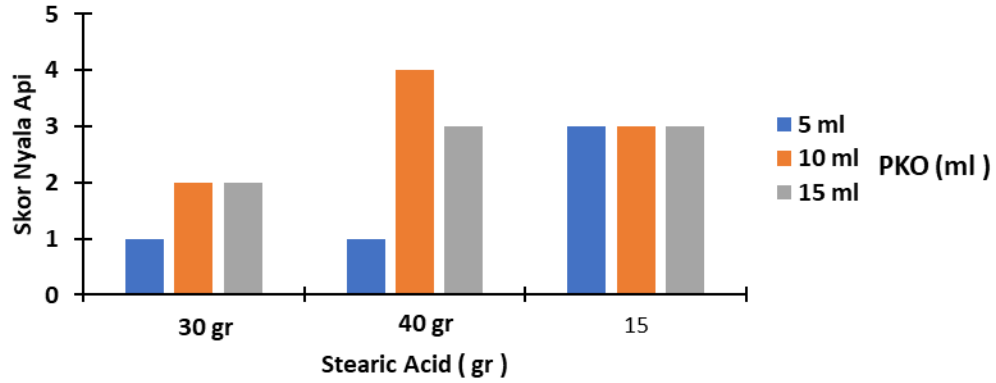

Fig 5. Flame Test

In the optimal aromatherapy candle flame test at a PKO volume of 10 ml with 40 gr of stearic acid occurred due to the balance of the composition which resulted in efficient combustion. This ratio creates a wax with an ideal hardness and melting point, which directly affects the way the wick attracts and burns the liquid fuel (wax melt). PKO provides enough liquid fuel, while stearic acid provides just the right hardness to ensure the wax doesn't melt too quickly. The viscosity of the dough is at an ideal point, allowing the capillary action of the axis to run efficiently. The wick can attract a stable and constant amount of wax melt to the top to be burned, resulting in an optimal, stable, and clean flame.

In the treatment of 40 gr with a PKO volume of 5ml ratio, stearic acid is very dominant. The mixture becomes too thick and has a very high melting point. As a result, the wax melts very slowly. The wick cannot absorb the

wax melt quickly enough to keep the flame large and stable. This condition causes the flame to become small and unstable, and can even die due to lack of fuel.

In this 15ml PKO treatment ratio, PKO is too dominant. The wax becomes too soft and has a low melting point. When the candle is lit, the melt pool becomes too large and forms quickly. The wick will be submerged in excessive wax melt. This results in the wick not being able to evaporate fuel efficiently and the flame becomes smaller and unstable, often flickering or producing soot due to incomplete combustion.

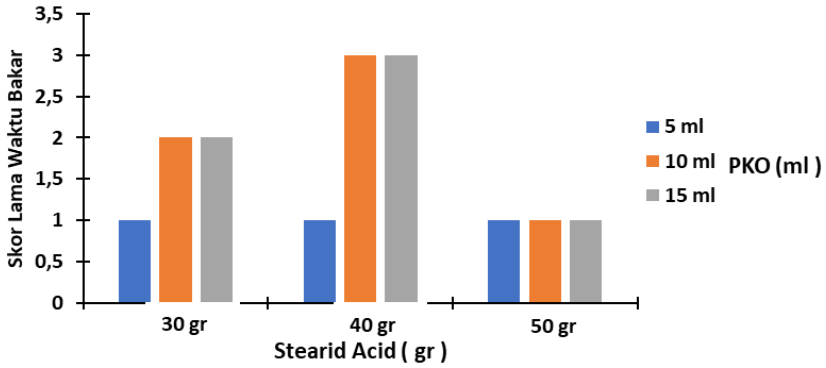

Fig 6. Burn Time Test

In the Long Burn Time Test with 40 gr of stearic acid treatment, it resulted in a more optimal burn duration at PKO volumes of 10 mL and 15 ml due to the balance of the wax composition. Proper comparison of materials ensures a stable and efficient combustion rate, so that the candle does not run out too quickly or too slowly.

In the treatment of 40 grams of Stearic Acid and 5 ml of PKO, the ratio of stearic acid to PKO was very high. The resulting wax will be very hard and have a high melting point. The wick will have difficulty melting the wax and absorbing the melt of the fuel. This causes the flame to become small and unstable, so the candle burns very slowly and wastefully. This process makes the wax not optimal because it takes too long to run out.

In the treatment of 40 grams of Stearic Acid with PKO of 10 ml and 15 ml, the ratio of PKO to stearic acid became more balanced. This balance creates a candle with optimal hardness and melting point. The wick is able to absorb the wax melt at an ideal rate, ensuring stable and efficient combustion. The wax does not melt too quickly or too slowly, resulting in an optimal and standard burn duration.

4. Conclusion

The comparison between PKO and stearic acid has a direct impact on the quality of aromatherapy candles. An insufficient amount of PKO results in wax that is too hard with a weak scent, while excessive PKO makes the candle soft, oily, and quick to wear out. Likewise, too much stearic acid produces overly hard wax that inhibits scent release, whereas too little leads to a less dense structure. Based on the testing results, the best formulation was achieved using 10 ml of PKO and 40 g of stearic acid, producing candles with a dense, smooth, and stable shape, homogeneous and attractive color, a strong and long-lasting aroma both before and after burning, a stable flame without black smoke, and an optimal burn time.

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