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Research Article

Development of Scented Candles Using Used Cooking Oil and Lemongrass Extract

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Abstract: *Improper disposal of used cooking oil results in water pollution, drainage clogging, and fire hazards. This study developed an eco-friendly aromatherapy candle using used cooking oil and lemongrass extract. The aim was to formulate and assess the performance of a sustainable candle. Three soy-wax-to-oil ratios (50:50, 60:40, 70:30) were prepared through melting, mixing, and moulding under controlled cooling. Burn time and fragrance intensity were evaluated and showed that 70:30 ratio exhibited the strongest scent retention and release, whereas the 50:50 ratio had the longest burn time but weak aroma. It can be concluded that 70:30 is the optimum sustainable formulation.*

1. INTRODUCTION

Used cooking oil (UCO) is generated in large quantities from household and food service activities, and improper disposal of this waste poses serious environmental concerns, including drainage blockage and water contamination. Previous studies have highlighted that inappropriate disposal of UCO contributes to environmental degradation and public health risks (Awogbemi & Kallon, 2024). The reuse of UCO in candle production provides environmental and economic benefits by reducing waste and creating a usable consumer product. Previous research has demonstrated that UCO-derived candles contribute to waste valorization, although their economic value may vary compared to other derivative products (Yuarini et al., 2021). The use of natural ingredients in candle manufacturing, such as soy wax made from soybean oil, is consistent with the principles of wellness

and sustainability. Soy wax advances the paradigm of environmentally conscious consumer choices by offering a strong substitute for traditional paraffin wax due to its renewable nature and biodegradability. (Hashim et al.,2024). Lemongrass extract, a plant known for its effective bioactive compounds like citral and geraniol (Sari et al., 2023), is well known as a natural agent that interferes with insect receptors and is widely used in aromatherapy and repellents (Faruki, 2024).

In this study, aromatherapy candles were produced by using recycled UCO and soy wax at different compositions, with lemongrass extract included as the aromatic component. The candle performance was evaluated based on scent strength, burning time, flame stability, and physical appearance.

2. LITERATURE REVIEW

UCO is primarily composed of triglycerides and free fatty acids, along with impurities formed during repeated heating cycles, such as oxidation products and contaminants (Yuarini et al., 2021). Many recycling and utilization techniques have been developed over the past 20 years, producing a variety of goods like cleaning agents, bio lubricants, and biodiesel. Due to its efficiency, the conversion of UCO into biodiesel has become a leading approach among these (Perumal 2024). However, there are exciting opportunities for sustainable innovation in alternate UCO usage methods, like the manufacture of wax. Particularly appealing is the manufacture of plant-based wax, which is abundant, biodegradable, and has a wide range of uses; candle making is one prominent example (Hashim et al.,2024).

UCO can be used as a primary ingredient in candle formulation when treated correctly, according to Yuarini et al. (2021), who created aromatherapy candles using UCO and other additives. The study also showed that UCO can improve the qualities of candles by combining it with other ingredients like stearic acid and scent chemicals. However, the applicability of UCO-based candles alone may be impacted by drawbacks including lower melting points and unstable combustion characteristics (Hashim et al., 2024). Therefore, to get desired performance, it is frequently required to combine UCO with structural waxes.

For years, petroleum-based paraffin wax has been used as the main component of candles. According to a study by Massoudi and Hamidi (2017), burning paraffin candles in confined spaces poses a risk to human health. The study examined a variety of paraffin candle types and found that the samples produced benzene, toluene, and alkenes. Compared to paraffin wax, soy candles showed far cleaner combustion profiles with significantly fewer particle, volatile organic compound, and nitrogen oxide emissions. These results confirm the superior role of natural wax substitutes in maintaining indoor air quality and reducing health risks associated with airborne contaminants (Balasubramani et al., 2026).

Due to its quality, composition, and pharmacological action, inhaling lemongrass essential oil helped female Generalized Anxiety Disorder (GAD) patients with their autonomic dysfunction. It can be suggested as a supplement to medication to lower cardiovascular risk because it is a safe, practical, and comfortable method (Chowdhury et al., 2024). The recent study introduces a natural insect-repellent candle made from used cooking oil and lemongrass extract, a plant known for its effective bioactive compounds like citral and geraniol (Ahmad et al., 2025). These natural agents are known to interfere with insect receptors and are widely used in aromatherapy and repellents (Faruki, 2024). The

findings support the viability of transforming household waste into value-added products, offering an eco-friendly alternative to chemical insect repellents while promoting environmental sustainability (Ahmad et al., 2025).

3. METHODOLOGY

3.1 Preparation of Used Cooking Oil

Used cooking oil was heated on a hot plate at 70–80°C. Activated charcoal was added to the heated oil and stirred thoroughly to remove impurities and unwanted odour. The oil was then filtered twice using a vacuum filtration setup to obtain purified oil. The purified oil was collected and stored in a glass container at room temperature for further use.

3.2 Preparation of Lemongrass Extract

Fresh lemongrass was washed thoroughly with clean water and cut into small pieces. The chopped lemongrass was blended with distilled water until a fine mixture was obtained. The mixture was then filtered, and the extract obtained was further concentrated using a rotary evaporator. The concentrated extract was stored in a closed glass container prior to candle formulation.

3.3 Formulation of Aromatherapy Candle

Soy wax was melted on a hot plate and mixed with purified used cooking oil according to predetermined ratios of 50:50, 60:40, and 70:30 (soy wax: oil). A small piece of crayon was added to the mixture. Subsequently, 30 drops of lemongrass extract were added to the mixture and stirred continuously to ensure homogeneity. The molten mixture was then poured into a candle container and allowed to cool and solidify at room temperature for 30 minutes.

3.4 Evaluation of Candle Performance

The formulated aromatherapy candles were evaluated based on appearance, burning time, flame stability, and aroma release. Each evaluation was conducted in triplicate for all three formulations, namely EX–50:50, EX–60:40, and EX–70:30. The appearance evaluation was based on the visual surface texture of each candle, while burning time analysis was assessed on total burning duration until the candle self-extinguished. Flickering behaviour and flame consistency were determined during the burning process to assess flame stability. On the other hand, the scent strength of the lemongrass extract was qualitatively evaluated during candle burning and recorded as weak, light, or moderate. All observations were recorded systematically to assess the overall performance and effectiveness of each aromatherapy candle formulation.

4. FINDINGS

The experimental results were obtained from different ratios of soy wax to used cooking oil, based on physical properties, burning performance, and scent strength of the formulated candles. Three formulation ratios were selected, labelled as EX–50:50, EX–60:40, and EX–70:30 (soy wax: used cooking oil), with a constant amount of lemongrass extract throughout the experiment.

4.1 Physical appearance of formulated candles

The physical appearance of the formulated candles was evaluated after solidification through visual assessment of their surface texture. The EX-50:50 and EX-60:40 formulations exhibited smooth and uniform surfaces, indicating good compatibility between the soy wax and extract at these ratios. In addition, the EX-50:50 formulation has a slightly shiny surface due to an equal ratio of soy wax to used cooking oil. In contrast, the EX-70:30 candle exhibited a rough surface texture, which may be attributed to the higher extract content interfering with the wax crystallization process during cooling. The physical appearance of the formulated candle is shown in Figure 1.

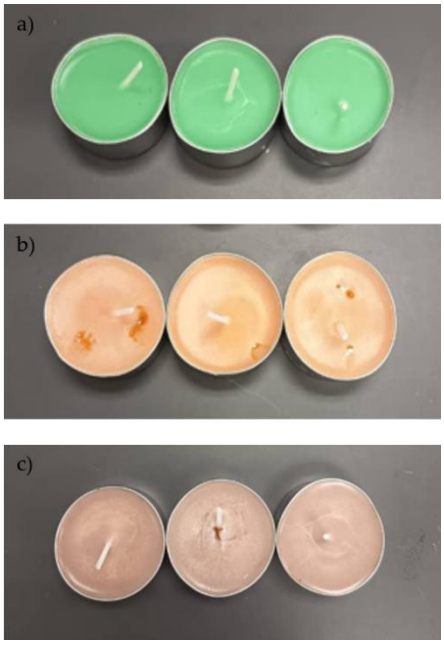


Figure 1. Formulated candle using different ratios added with lemongrass extract a) EX–50:50 b) EX–60:40, and c) EX–70:30.

4.2 Evaluation of the performance of formulated candles

Performance of each ratio formulated candle was assessed in terms of burning time, flame stability, and scent strength. Each assessment was tested in triplicate. Burning time was determined by measuring the duration from ignition to complete extinguishment, whereas flame stability was evaluated through continuous visual observation during combustion. The EX-50:50 formulation demonstrated the longest burning time of 1 hour and 40 minutes and maintained a stable flame throughout the test. Decreasing the used cooking oil content to 40% (EX-60:40) resulted in a shorter burning time of 1 hour and 14 minutes, accompanied by slight flame instability. Meanwhile, the EX-70:30 formulation exhibited a burning time of 1 hour and 24 minutes with a stable flame. These findings indicate that decreasing the used cooking oil content generally reduces burning time, likely owing to the higher volatility of the used cooking oil component, which promotes faster fuel consumption during combustion.

On the other hand, the scent strength of formulated candles was evaluated based on sensory observation during candle burning. At a 50:50 ratio, the candle exhibited a very weak scent throw, with

the fragrance being barely noticeable. Increasing the soy wax content to a 60:40 ratio resulted in a light fragrance that was detectable but faded quickly during burning. The strongest and most noticeable scent was observed at a 70:30 ratio, where the fragrance intensity was moderate and remained perceptible during combustion. These results indicate that increasing the proportion of essential oil relative to soy wax enhances scent strength. The overall performance of formulated candles was presented in Table 1.

Table 1. Assessment of performance of formulated candles

Sample	Burning Time	Flame Stability	Scent Strength
EX – 50:50	1 hour 40 minutes	Stable	Very weak scent throw, fragrance barely noticeable
EX – 60:40	1 hour 14 minutes	Slightly unstable	Light fragrance detected but fades quickly
EX – 70:30	1 hour 24 minutes	Stable	Moderate scent strength, fragrance is noticeable

5. DISCUSSION

5.1 Physical appearance of formulated candles

The experimental results indicate a significant correlation between the liquid-to-solid ratio and the surface texture of the candles. In formulations EX–50:50 and EX–60:40, the smoother surface texture is a result of the plasticizing effect provided by the higher oil concentration. An increased ratio of oil in the formulation dilutes the solid phase and slows down wax crystal growth, thus inhibiting agglomeration and forming a fine, homogeneous microcrystalline network (Dhal et al., 2023). In addition, the liquid phase reduces the intermolecular forces between wax molecules. This significantly hinders the rate of nucleation at the initial stage of solid-phase formation. The incorporation of liquid oil into the soy wax matrix slows down wax solidification. Consequently, increasing the liquid oil proportion reduces crystal growth rates, preventing the formation of large crystalline aggregates (Sena et al., 2022). In contrast, the EX–70:30 sample exhibited a rough surface, a phenomenon driven by accelerated crystallization kinetics. Formulations with higher wax content favour the growth of a dense crystalline network. Higher wax-to-oil ratios lead to stronger crystalline material formation, which often demonstrates as a more textured or irregular surface rather than a smooth, creamy finish (Jana, S, 2016).

5.2 Evaluation of the performance of formulated candles

The burning time results show that the soy wax to used cooking oil ratio significantly influenced combustion behaviour. The EX-50:50 sample exhibited the longest burning time, which is 1 hour and 40 minutes, while EX-60:40 burned for the shortest duration of 1 hour and 14 minutes, and EX-70:30 showed a slightly longer duration, which is 1 hour and 24 minutes. Increasing soy wax content enriches long-chain triglycerides characterized by strong intermolecular forces and low volatility. Consequently, it will slow fuel vaporization and combustion, resulting in longer burn times (Rezaei, Wang & Johnson, 2002). A study reported that increases in solid wax portion typically extend candle lifetime due to enhanced melting point and controlled fuel release in waste oil-based formulations (Hashim et al., 2024). The outstanding performance of EX-50:50 over EX-60:40 indicates that a balanced wax-oil ratio is essential for optimal fuel transport and flame stability. This balance improves capillary flow of the molten fuel to the wick, ensuring a stable combustion process. On the contrary, ratios like

EX-60:40 disrupt this equilibrium, causing deficient viscosity and irregular melt pool formation that impair efficiency (Liu et al.,2022).

Scent strength changes across different wax-to-oil ratios (EX-50:50, EX-60:40, EX-70:30) depending on how well the wax holds and releases the fragrance (Rezaei et al., 2002; Hashim et al.,2024). The lowest soy wax proportion (EX-50:50), the fragrance throw was very weak and barely noticeable, likely due to the high proportion of liquid oil diluting aromatic compounds and reducing their retention within the wax matrix (Liu et al., 2022). The EX-60:40 ratio improved early scent strength but faded quickly because it still had insufficient wax content for a long-lasting release. (Hashim et al., 2024). The highest soy wax ratio (EX-70:30) produced a longer-lasting, moderate scent, showing that a higher ratio of soy waxes is able to lock in fragrance compounds and control their release during combustion (Rezaei et al., 2022). This behaviour is consistent with the known properties of soy wax, whose triglyceride-based structure promotes a slower and more sustained release of volatile compounds than more fluid systems, owing to its lower melting point (Rezaei et al., 2002; Liu et al., 2022). In addition, the chemical composition of the lemongrass extract comprises a mixture of volatile aldehydes and terpenoid alcohols together with non-volatile plant constituents. Because these volatile compounds are present at relatively low concentrations and are diluted by non-aromatic components, plant extracts generally exhibit a weaker scent throw than essential oils, which consist predominantly of highly volatile aromatic compounds. (Muala et al., 2021).

6. CONCLUSION

Aromatherapy candles were successfully formulated using used cooking oil and soy wax, demonstrating that used cooking oil can be applied as an alternative raw material for candle production. The EX-70:30 ratio showed remarkable performance with significant burning time, flame stability, and scent strength. Investigations on burning time and physical characteristics showed that the soy wax to oil ratio influenced candle performance. Candles with higher soy wax content exhibited longer burning times and more stable flames, while higher oil content resulted in shorter burning times and less uniform physical appearance. In conclusion, the formulated aromatherapy candles met the intended performance criteria, and the objectives of formulation and performance evaluation were successfully achieved.

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