Evaluating Coffee Essential Oil for Sustainable and Natural Perfume Formulations

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Abstract

Perfumes are widely used cosmetic products that enhance personal appeal and boost self-confidence. Perfumes can be classified based on the proportion of fragrant oil, alcohol, and boosters derived from natural essential oils produced by aromatic plants. This study focuses on the development of a natural perfume formulation using coffee 434 essential oil, a novel ingredient with distinct aromatic properties and potential health benefits compared to synthetic perfumes. The research utilises an experimental approach that involves the extraction process of coffee 434 essential oil using Soxhlet and perfume formulation, assessment, and final product creation. Various fragrance blends were formulated by combining the essential oil with scents such as strawberry, peach, and vanilla. These formulations were evaluated for physiochemical properties, including pH, scent longevity, spot testing, flammability, and Fourier-transform infrared (FTIR) spectroscopy. Results showed that Strawberry B, Peach B, Vanilla A, and Original A exhibited the longest-lasting scents with minimal flammability. The FTIR spectra (400–4000 cm^{-1}) revealed O-H stretching vibrations of hydroxyl groups in coffee essential oil, peaking between 3000 and 2500 cm^{-1}. Notably, Peach B and Vanilla A achieved scent longevity up to 50 minutes and diffusion distances of 79 cm, confirming their suitability for personal use. These findings have significant implications for the local fragrance industry, highlighting the potential of coffee 434 essential oil to support sustainable and health-conscious alternatives to synthetic perfumes. By integrating natural ingredients, manufacturers can address growing consumer demand for eco-friendly products, reduce environmental impact, and offer safer options, positioning these formulations for wider adoption in both local and international markets.

Keywords: Coffee Essential Oil, Eco-Friendly Fragrances, Natural Fragrance Formulations, Scent Longevity, Soxhlet Extraction

1.0 Introduction

Perfumes are complex chemical compounds that combine specific formulas to produce a variety and unique aromas. These fragrances play a vital role in enhancing personal attractiveness, improving comfort, and boosting self-confidence due to their pleasant scents [1], [2]. Over time, there has been a

growing demand for more natural and sustainable fragrance alternatives, driven by increasing consumer awareness of the environmental and health impacts of imitation perfumes. Coffee, a globally popular beverage known for its unique scent. It is produced from over 80 varieties of coffee, which together contribute to approximately 60% and 40% of the world's coffee output, respectively [3].

The chemical composition of coffee, which includes compounds such as caffeine, chlorogenic acid, trigonelline, diterpenes, phenolics, and volatile organic compounds (VOCs), gives coffee its distinct aroma and a wide range of biological effects, including antioxidant, antibacterial, and anticancer properties [3]. VOCs, in particular, are considered to be the primary contributors to coffee's aromatic profile and significantly influence its quality and consumer appeal. Despite the numerous studies on coffee's chemical components, there has been limited research on the use of coffee essential oils, especially coffee 434 essential oil, for fragrance applications.

The aroma of coffee plays a pivotal role not only in its popularity as a beverage but also in the development of perfumes. The process of brewing, particularly the boiling stage, is key to releasing odour-active volatiles from ground coffee into the extract. Several factors such as temperature, time, water volume, and pressure affect the release of these aromatic compounds [4]. Several studies have focused on identifying the volatile compounds in coffee, using methods like solid-phase micro-extraction to analyse freshly brewed Arabica coffee and examining the impact of roasting conditions on fragrance [3], [5], [6], [7]. However, research into coffee's aromatic potential for perfume formulations remain underexplored.

Figure 1 depicts pyramid of scents perception proposed by Teixeira et al. [8]. This pyramid illustrates the hierarchical mechanisms of scent perception. It consists of four interconnected layers essential for perfumers. At the base, emotions are shaped by culture, memories, and experiences, while the third layer offers an objective classification using descriptors like "cool," "warm," "dry," "fatty," and "strong." At the top, perfumers apply the most neutral classification to refine the fragrance hierarchy. However, these descriptors can vary and remain subjective, even for identical scent components or blends [8].

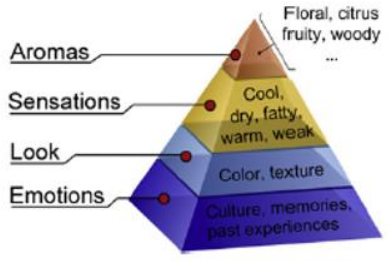

Figure 1: The pyramid of scents perception [8]

This study addresses the gap by focusing on coffee 434 essential oil, sourced from Muar, Johor, Malaysia, to explore its potential for use in natural perfumes. The research aims to evaluate the pH value, aroma longevity, flammability, and spot testing of the oil, alongside Fourier-transform infrared (FTIR) analysis to determine its chemical composition. Despite the growing interest in essential oils for sustainable fragrance production, coffee 434 essential oil has not been studies for its fragrance properties, making this research a novel contribution to the field.

The findings from this research will offer valuable insights into the physiochemical properties of coffee 434 essential oil and its potential as a natural alternative to synthetic fragrances. By providing a detailed analysis of its scent longevity and chemical profile, this study contributes to the growing interest in eco-friendly and health-conscious products within the perfume industry. The results may pave the way for the development of sustainable fragrance alternatives. These would eventually offer a shift toward natural, environmentally friendly perfumes that meet the rising consumer demand for healthier and more sustainable options.

2.0 Methodology

2.1 Reagents and Coffee 434 Preparation

The ethanol of analytical quality (99.9%) was acquired from Merck, located in Darmstadt, Germany. In the meantime, ground booster, scented oil (strawberry, peach, vanilla, original), and 100% origin coffee 434 (1 kg) were bought at the local market.

2.2 Soxhlet Extraction Method

The Soxhlet extraction method was used to extract oil from coffee 434. The extraction of ground coffee 434 was carried out in ethanol, whereas the solvent was used is most suited for the process of isolating volatiles from coffees [9]. Before extraction, shows 40 mL of ethanol in a boiling flask and 10 gram of grinded coffees 434 for 55 min at the syphon area (Figure 2).

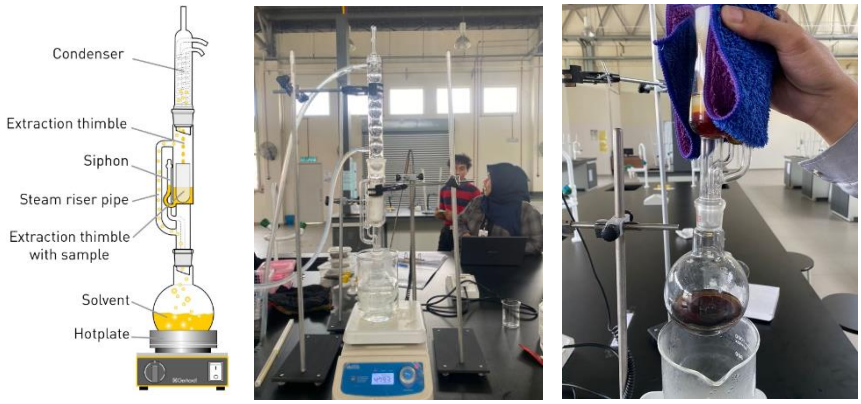

Figure 2: The extraction process of Coffee 434 [10]

2.3 Procedure of Making Perfume

The process of creating a coffee-based perfume entails extracting the fragrant components from coffee beans and combining them with other compatible fragrances to obtain a specific fragrance. The method for creating a scent with coffee was developed [9]. Mix the 5 ml of fragrance or essential oils with the 6 ml of coffee extract. Blends of strawberry, vanilla, peach, and original smells were used to enhance the aroma of coffee. To create the appropriate aroma, adjust the ratios of coffee extract to other scents plus booster. Remember that the scent could change with time, so give the mixture a week to settle before making any final decisions. Filtering process with a coffee filter or fine mesh strainer if detect any sediment or contaminants in coffee 434 perfume. Pour the perfume into tiny, opaque glass bottles using a funnel. The aroma is better shielded from light exposure in dark bottles. Put the ingredients and manufacturing date on the label of your perfume. To keep the scent fresh, store the bottles somewhere cold and dark.

2.4 Physicochemical Characteristic of Coffee 434 Oil

The components used in the creation of the essential oil perfume Coffee 434 are a carefully chosen combination intended to create an olfactory harmony consistent with the desired fragrance qualities. The sixteen experimental formulations show differences in the concentrations of their ingredients. Table 1 provides a detail breakdown of Coffee 434 fragrance additives of the components that make up the recipe for the essential oil perfume known as Coffee 434.

Stirring the solution until it reached a state of homogeneity allowed for the preparation of the final product. Each fragrance oil substance was treated as a completed product. Therefore, fragrance oil ingredient was precisely weighed to the appropriate concentration before being mixed with the perfume solvent. The resultant solution was agitated for about 10 seconds prior to being put into a perfume bottle.

Table 1: Coffee 434 fragrance additives

No	Scented type	Scented oil (ml)	Coffee 434 essential oil (ml)	Perfume Booster (ml)	Ethanol (ml)
1	Strawberry	5% (5ml)	2 ~ 8% (2~8ml)	1~4ml	1~4ml
2	Peach				
3	Vanila				
4	Original				

2.5 pH Tests

The pH level of a scent was conducted by using Knick 766 Climate pH meter, indicating its degree of acidity or alkalinity. Calibrate the pH meter using standard buffer solutions at pH 4.0, 7.0, and 10.0 to ensure accurate readings. Immerse the pH electrode into the perfume sample and wait for the reading to stabilize. It's important to note that some perfumes may contain volatile compounds that can evaporate quickly, so it's best to cover the sample container during measurement to minimize evaporation. Record the pH

reading from the pH meter display.

The perfume's qualities are not entirely determined by its pH level. The overall performance and sensory experience of the perfume are influenced by several aspects, including the kind and concentration of fragrance compounds, the presence of stabilizers, and the quality of the carrier (alcohol or oil) [8]. Perfume composition involves several steps beyond the pH test. When developing a scent, perfumers often think about the aroma's character, how long it will last, and how it will make the wearer feel.

2.6 Scent Long-lasting Test

The longevity of a perfume is determined by observing the length of time that the scent remains detectable on clothing or the skin following application. Numerous factors, such as the amount of aroma oils present, the selection of the ingredients, and the product's formulation, affect how long a perfume lasts [9].

The aroma persistence was assessed by spraying the perfume solution on test sheets. The olfactory attributes were assessed using the sense of smell, with the fragrance being sniffed at a fixed distance of 10 cm from the nose for a period ranging from the first application to the end of the four hours. Perfume was deemed to have achieved lasting intensity if its scent remained detectable for the duration of this four-hour period [9].

2.7 Spot test

The spot testing process involves putting the perfume solution onto a piece of brightly coloured paper and then using a measuring tape to determine the diameter of the resulting spot. The outcome demonstrated that the scent dispersion area was expanded, indicating a greater level of quality [13].

2.8 Flammable Test

Conducting a flammability test for a perfume is crucial, particularly when handling items that include alcohol is a common base for many fragrances. Pour a modest quantity of the fragrance into the glass beaker or container. Next, let the perfume sit for a brief period to ensure the uniform dispersion of any alcohol vapours. The ignition source or long-handled lighter should be lit. With caution, approach the flame near the perfume's surface within the container. Avoid submerging the flame directly into the perfume. Determine the perfume's effects. The presence of ignition signifies flammability. Calculate the time it will take for the flame to completely extinguish itself or for your intervention to occur. Ensuring the safety of the product is of utmost importance, especially when it contains alcohol or other flammable ingredients [14].

2.9 Fourier Transformed Infra-Red (FTIR)

The Fourier transform infrared spectroscopy (FTIR) technique was used to find the liquid particles on the peak of infrared absorption spectra. Therefore, the FTIR was used on Coffee 434 perfume samples to find the active surface functional groups. The infrared (IR) spectra were obtained using the Perkin Elmer (PE) Spectrum 100 FTIR spectrometer. The scans were gathered with a resolution of 4 cm^{-1} to get the infrared spectra, which were obtained between 400 and 4000 cm^{-1}.

3.0 Results and Discussion

3.1 pH Value of Coffee 434 Perfume

Perfumes often have a pH that falls between 4 and 7. The pH level is not sufficient to provide a complete description of the qualities of a scent [11]. The overall performance and sensory experience of the perfume are influenced by several aspects, including the kind and concentration of fragrance compounds, the presence of stabilisers, and the quality of the carrier (alcohol or oil). Figure 3 shows the pH levels of perfume used in the study. The result shown that the pH value of all perfume sample is in range 6.0-7.5, being considered almost neutral range. Therefore, the effect of formulation needs to adjust depending on pH value is important when making perfume. Nevertheless, the significant modifications may influence the overall formulation and durability of the fragrance.

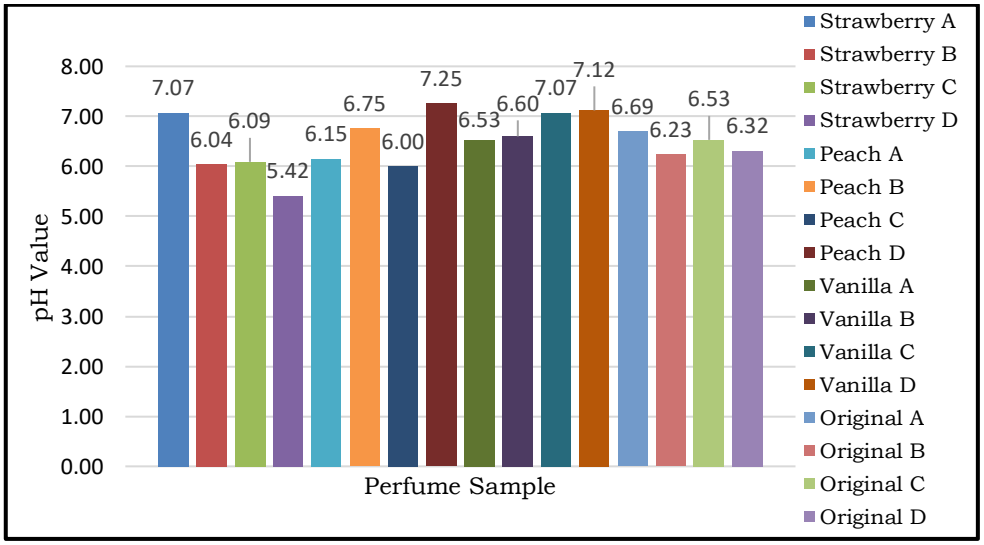

Figure 3: pH levels

Although pH is often not a crucial element in perfume composition, it may impact the stability and longevity of the fragrance [11]. Most fragrances tend to be low acidic, however a perfume's pH level could not provide us with a whole picture of its qualities.

Table 2: Long-lasting, spot diameter and flammable of coffee 434 perfume

Scented type	Times (t) / Criteria Scent	Diameter (cm)	Flammable Test
Strawberry A	40 (Strong)	75	Non-Flammable
Strawberry B	40 (Strong)	76	Non-Flammable
Strawberry C	30 (Normal)	73	Low-Flammable
Strawberry D	30 (Normal)	74	Medium-Flammable
Peach A	40 (Strong)	74	Non-Flammable
Peach B	50 (Very Strong)	79	Non-Flammable
Peach C	30 (Normal)	73	Non-Flammable
Peach D	30 (Normal)	73	Low-Flammable
Vanila A	50 (Very Strong)	79	Non-Flammable
Vanila B	40 (Strong)	75	Non-Flammable
Vanila C	30 (Normal)	73	Low-Flammable
Vanila D	30 (Normal)	72	Medium-Flammable
Original A	50 (Very Strong)	78	Non-Flammable
Original B	40 (Strong)	76	Non-Flammable
Original C	30 (Normal)	74	Non-Flammable
Original D	20 (Week)	72	Low-Flammable

3.2 Scent Long-lasting Test

The assessment of the long-lasting coffee 434 perfume was successfully conducted, as the aroma remained perceptible for at least 4 hours after being sprayed over the paper [9]. The durability smell test was conducted for a duration ranging from 10 min (minimum time) to 50 min (maximum time). The test evaluated five distinct fragrance criteria, namely very strong, strong, normal, weak, and very weak, at different time intervals. The study results are presented in Table 2. According to the results of the durability test, the fragrances Peach B, Vanila A, and Original A, which are used in the formulation of coffee 434 perfume, have odours that stay longer than those of other fragrances.

Nevertheless, the fragrance of the Original D formulation is not long-lasting. The reason is that formulations A and B have a greater concentration of fragrance oil at the base note level compared to formulations C and D. Perfume were utilised in this study are not only as base formula components but also as fixatives. Fixatives are used to equalize the vapor pressures and thus the volatilities of the raw materials in a perfume oil. Therefore, the quality of the volatile component mixture and fixative substances in the formulation impact the durability of the fragrance.

Fixatives are elements used in perfumery that have less volatility than other chemicals. This allows them to slow down the pace at which scent evaporates. These ingredients are added to the fragrance oil to extend its shelf life and speed up the evaporation process. A high boiling point and a pleasing scent are two qualities that make a material an excellent fixative [12].

3.3 Spot Test

The assessment results for the spot test of coffee 434 perfume were collected by using a measuring tape to measure the diameter of each spot produced by each formula. Based on the findings of the tests, the average spot diameter for all the formulations was found to be 74.75 cm. According to Oyinbrakemi Golda [13], the spot diameter of perfume formulations is determined by the amount and diameter of the scent employed. This result agrees with the Oyinbrakemi Golda who performed perfume using lemongrass leaves, whereas the highest of the spot diameter shows a great quality of perfume such as Peach B and Vanila A with 79 cm, respectively.

3.4 Flammable Test

The results indicate that the formulation of perfume employing Strawberry D and Vanilla D is moderately flammable compared to other formulations that are non-flammable or have low flammability. Perfumes often include alcohol and other combustible components and exposing them to an open flame or heat source may pose a substantial hazard. The best extraction ratio of alcohol showed that the highest conversion of 98.4% was obtained using ethanol to Coffee essential oil molar ratio of 1:3, which is in agreement with the one obtained from Ameh work using lemongrass [14]. Therefore, the manufacturer should provide detail information such as include specific data on the flash point and appropriate storage circumstances to avoid fires, explosions, and significant injurie.

3.5 Fourier Transform Infra-Red (FTIR)

Figure 4 shows the infrared spectra of scent samples within the 400–4000 cm^{-1} range. The peak seen at 3000 to 2500 cm^{-1} in the natural coffee 434 scent represents the C-H stretching vibration mode of the carbonyl groups. This peak is often found in hydrocarbons. The peak indicated that the samples as the intensity of the O-H bands increases in all types of fragrances used to produce the natural coffee 434 perfume. Furthermore, it is observed that the OH- ion adsorbed to the surface of free fatty acid (FFA) in coffee 434 essential oil triglycerides easily.

The chemical interaction between the OH ions and the FFA were influenced after the scented type and booster derived was added into the reactant ethanol. This interaction can alter the chemical properties and behavior of the FFA, potentially affecting the overall fragrance composition and performance. The absorption peaks ranging from 1000 to 2000 cm^{-1} serve as indicators of glycerol and O-H bond vibration in coffee 434 essential oil triglycerides, thereby enhancing the efficiency of the transesterification reaction [15].

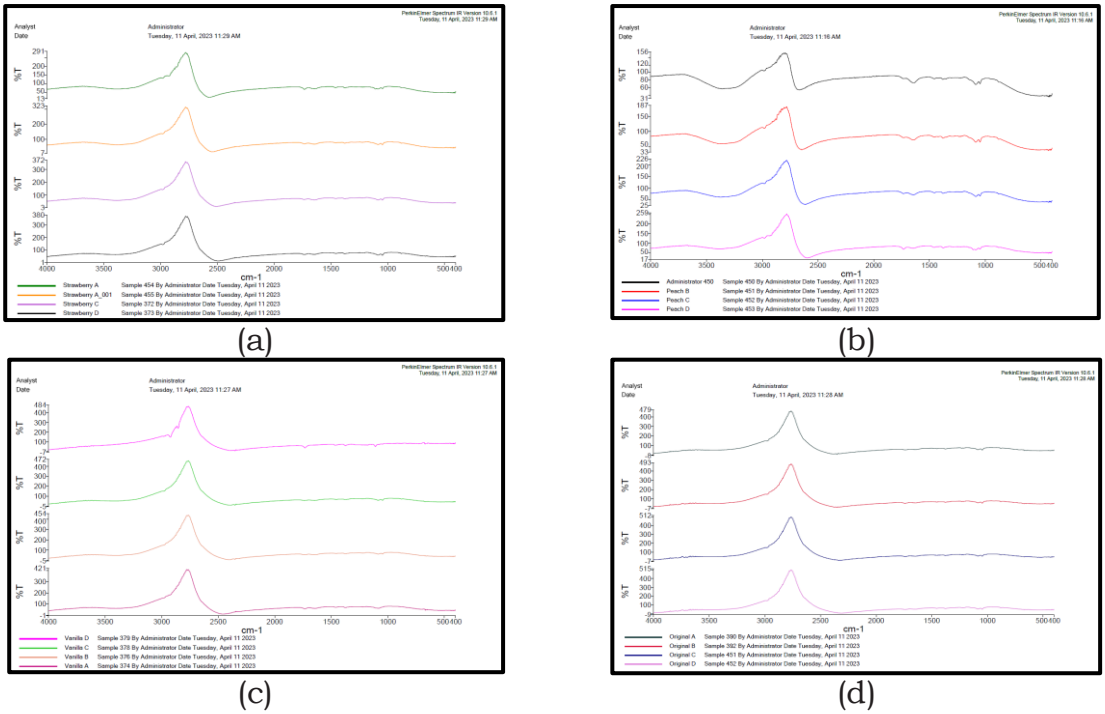

Figure 4: FTIR spectra of coffee 434 perfume (a) strawberry, (b) peach, (c) vanilla, and (d) original

4.0 Conclusion

This study successfully developed a natural perfume formulation using coffee 434 essential oil, demonstrating its distinct aromatic properties and potential health benefits as a sustainable alternative to synthetic perfumes. The optimal scent composition included Strawberry B (40, strong), Peach B (50, very strong), Vanilla A (50, very strong), and Original A (50, very strong), all with minimal flammability, as well as clarity, stability, and safety for human use. Among the formulations, Peach B and Vanilla A were the most notable, with the longest-lasting aromas and a diffusion diameter of 79 cm, highlighting their effectiveness and appeal. These findings suggest strong potential for commercializing coffee 434-based natural perfumes as eco-friendly, health-conscious products. Future research could focus on scaling up production, optimizing extraction methods for sustainability and cost-efficiency, and employing advanced encapsulation techniques to further improve scent longevity while evaluating consumer preferences in diverse markets.

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Author Contributions

M. A. M. Ali: Oil Extraction, Methodology, Supervision, Writing-Original Draft Preparation, Writing-Reviewing and Editing; **H. R. M. Nor**, **M. D.**

Suhardiman, and **M. D. F. M. Razif**: Experiment Setup, Data Curation, and Validation.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission and declare no conflict of interest in the manuscript.

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