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Formulation and Quality Control Assessment of Oil- and Alcohol-Based Fragrance Oils Exploring the Rosemary and Vanilla Fragrance Oils

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Abstract

Background: Fragrance oils are widely used in personal care products, with formulations typically based on either alcohol or oil carriers. While alcohol-based perfumes are known for strong projection, oil-based perfumes are increasingly preferred for their longevity and skin compatibility. However, limited comparative data exist on their formulation characteristics and performance.

Objectives: This study aimed to formulate oil-based and alcohol-based fragrance oils using rosemary and vanilla, and to comparatively evaluate their physicochemical properties, stability, and performance characteristics.

Methods: Two formulations were prepared using standard procedures with ethanol and olive oil as respective carriers. Quality control assessments included colour, odour, pH, skin irritation, viscosity, density, spreadability, greasability, stability, sensory evaluation, sillage, and adhesion tests. Standard laboratory techniques such as U-tube viscometry and picnometry were employed, alongside panel-based sensory evaluation.

Results: Both formulations were clear, stable at room temperature, non-irritant, and exhibited skin-compatible pH values (4–5). The alcohol-based fragrance showed lower viscosity (0.29), lower density (0.994), and higher spread ability (300 gcm min^{-1}), with stronger initial scent intensity and higher sillage. In contrast, the oil-based formulation demonstrated higher viscosity (2.49), higher density (1.03), lower spread ability (50 gcm min^{-1}), increased greasiness, stronger adhesion, and prolonged scent retention. Sensory evaluation indicated higher intensity for the alcohol-based formulation, while adhesion and longevity favored the oil-based formulation.

Conclusion: Both formulations met acceptable quality standards, but differed significantly in performance. Alcohol-based fragrance oils are more suitable for immediate scent projection, whereas oil-based formulations provide longer-lasting and skin-friendly effects. The study highlights the importance of carrier systems in determining fragrance behavior and consumer preference.

Keywords: Fragrance oil, alcohol-based perfume, oil-based perfume, viscosity, spread ability, sillage.

INTRODUCTION

Perfume is a fragrant liquid that is sprayed or rubbed on the skin or clothes to give a pleasant smell. Extraction of perfume from various plants resources is of ancient origin. Human since the ancient time have known how to extract oil from their natural resources. Vegetable oils are naturally occurring esters of higher fatty acids and glycerol. They are widely distributed in nature and were first consumed as food. Primary components of oil perfumes include essential oils derived from plants, synthetic aroma compounds, and carrier oils such as jojoba,

fractionated coconut oil, or sweet almond oil. The absence of alcohol in these perfumes makes them more skin-friendly, reducing the risk of irritation for sensitive individuals. [1]

The oil-based formulation allows for a longer-lasting scent, as oils tend to evaporate more slowly than alcohol-based solutions. [2] Advantages of Oil Perfumes; longevity, Oil perfumes are known for their staying power. The oil base allows the fragrance to linger on the skin for extended periods compared to traditional perfumes.[3] Skin Compatibility, many people find oil perfumes less irritating to their skin, making them a suitable option for those with sensitivities to alcohol or synthetic fragrances.[4] Versatility, these perfumes can be used in various forms, including roll-ons, sprays, and solid formats, allowing users to choose their preferred method of application.[5] Environmental Impact, many oil perfumes use natural ingredients, which can be more environmentally friendly compared to mass-produced alcohol-based fragrances.[6]

Despite the growing popularity of oil perfumes, there is limited academic research exploring their efficacy and consumer perceptions compared to conventional fragrances. Many consumers remain unaware of the benefits of oil-based scents, including their longevity and moisturizing properties. [6]

Additionally, the lack of standardized formulations in the oil perfume market raises questions about quality and effectiveness, necessitating a deeper investigation into these products. Fragrance oil enhances personal scent and boost confidence by masking or complementing natural body odours. Consumers are becoming more conscious of the ingredients in their beauty products, opting for those that are free from synthetic additives and harmful chemicals. [7]

This study aimed at producing a stable alcohol-based fragrance oil and oil-based fragrance oil and compare both based on their similarities and differences, and efficacy based on lasting scents. This study also provides valuable insights into consumer behavior regarding oil perfumes, helping brands to tailor their marketing strategies effectively. By highlighting the benefits of oil-based fragrances, the research could encourage consumers to explore these options, leading to increased sales in this segment of the market. Additionally, the findings may inform product development, guiding manufacturers in creating high-quality oil perfumes that meet consumer needs. [8]

Research into oil perfumes can enhance knowledge about skin compatibility and potential allergens. As more consumers seek hypoallergenic products, studies can guide manufacturers in creating safer fragrances that minimize irritation. [4] This focus on health is crucial, especially for individuals with sensitivities or allergies.

With increasing concerns over environmental sustainability, studying the ingredients and production methods of oil perfumes can lead to more eco-friendly practices. Understanding how to source natural materials responsibly can help reduce the environmental footprint of the fragrance industry. [6] The rise of oil perfumes reflects changing consumer preferences towards natural and organic products. By studying these trends, businesses can better align their marketing strategies and product development with consumer demands. [7]

MATERIALS AND METHODS

Materials

Table 1: Materials Used

Alcohol-Based Fragrance Oil	Quantity (mL)	Oil-Based Fragrance Oil	Quantity (mL)
Ethanol	70 mL	Rosemary and Vanilla Fragrance oil (Fragrance oil)	20 mL
Propylene glycol	5 mL	Olive oil (Carrier oil)	20 mL
Rosemary and Vanilla Fragrance oil (Fragrance oil)	25 mL	Isopropyl MyState Tetrad conic Acid	2 mL
Fixative	2 drops	Fixative (Ehylhexyl Glycerin)	2 drops

Preparation of Alcohol-Based Fragrance Oil

A 25 mL quantity of the fragrance oil was measured and transferred into a glass beaker and stirred gently to mix. A 70 mL quantity of ethanol was measured and added to the fragrance oils. The mixture was stirred gently and thoroughly to ensure even distribution. A 5 mL Propylene glycol was measured and added to the mixture with proper and thorough stirring. A 2 drop of the fixative was measured and incorporated by mixing gently with the mixture. The prepared fragrance oil was then transferred into a dark glass bottle to protect it integrity and quality from sunlight. The fragrance oil was appropriately packaged and labelled.

Preparation of Oil-Based Fragrance Oil

A 20 mL quantity of the fragrance oil was measured and transferred into a glass beaker and stirred gently to mix. A 2 mL quantity of Isopropyl myristate tetra-deconic acid was measured and added to the fragrance oils. The mixture was stirred gently and thoroughly to ensure even distribution. A 20 mL Olive oil (carrier oil) was measured and added to the mixture with proper and thorough stirring. A 2 drop of the fixative was measured and

incorporated by mixing gently with the mixture. The prepared fragrance oil was then transferred into a dark glass bottle to protect it integrity and quality from sunlight. The fragrance oil was appropriately packaged and labelled.

Quality Control Assessment of Fragrance Oil

Colour Test for Fragrance Oil

The color test for fragrance oils is a simple method used to assess the quality and characteristics of the oil. While it is not a definitive measure of purity, color can provide insights into the composition and potential presence of certain components.

Purpose of the Colour Test

a. Quality assessment: Color can indicate the presence of impurities or degradation in the fragrance oil.

b. Comparative analysis: It allows for comparison between different batches or brands of fragrance oils.

Procedure

It was ensured that the workspace was clean. A small sample of fragrance oil was poured into a clear glass vial. The vial was placed against a white background. The colour was observed and results were recorded.

Odour Test for Fragrance Oil

The odour test for fragrance oils is an essential method used to evaluate the scent profile and quality of the oil. This sensory evaluation allows perfumers and consumers to assess the fragrance's characteristics, including its strength, complexity, and overall appeal.

Purpose of the Odour Test

a. Quality Assessment: Evaluating the scent can help identify impurities or inconsistencies.

b. Profile Development: Helps in understanding the fragrance’s top, middle, and base notes.

Procedure

It was ensured that the workspace was cleaned. A cotton pad was dipped into the fragrance oil sample. The cotton pad was held 2 inches away from the nose and was inhaled gently to evaluate the initial scent (top note). It was then set aside for few minutes to allow the middle note to emerge, and the scent was inhaled again. It was allowed to sit for 10minutes and the scent of the base note was gently inhaled and results were recorded.

pH

The pH test for fragrance oils is an important procedure used to assess the acidity or alkalinity of the oil. While most fragrance oils are typically neutral, variations can occur based on the composition and the presence of certain additives.

Purpose of the pH Test

a. Quality Control: Identifying the pH level helps determine if the fragrance oil is suitable for cosmetic use or if it may cause skin irritation.
b. Formulation Adjustments: Knowing the pH can inform whether adjustments are needed in the formulation to achieve the desired stability and compatibility with other ingredients.

Procedure

The pH test strip was dipped into the fragrance oil. Excess fragrance oil was allowed to drip out, and the colour change was compared to the pH scale, and results were recorded.

Skin Irritancy and Sensitization Test

Procedure

A small area of skin, typically on the inner forearm or behind the ear was cleaned with an alcohol swab and let to dry. A cotton swab was dipped into the fragrance oil and placed on the skin**, and** was then left for a couple of minutes and was monitored for any signs of irritation. The swab was removed and the skin still observed for 24hrs to check for any delayed reactions. The results were appropriately recorded.

Viscosity Test

Procedure

The U-tube viscometer was filled at one end up to the marked line as per the manufacturer's instructions. The tube was sucked using the other end to the marked line. The stopwatch was started and stopped when it reached the end mark. The time taken for the liquid to flow between these two points were recorded. Viscosity was calculated.

Spread ability Test

Procedure

Two glass slides were gotten. A drop of the fragrance oil was placed on the center of one slide. The other slide was placed on top and a weigh bar was placed on top. It was timed for 10minutes and the diameter of spread was measured, and results were recorded in triplicates and spread ability was calculated.

Density Test

Procedure: The weight of the empty picnometer was recorded. The picnometer plus water was weighed and result was recorded. The weight of picnometer plus fragrance oil was measured in triplicates and results were recorded. Density was calculated.

Greasability

Test Procedure: A clean and dry watch glass or shallow dish was used for the test. Weigh of the empty watch glass or dish was gotten and recorded. A measured amount of the oil perfume was added to the dish and weighed again to get the total weight. The initial weight of the watch glass with the perfume was recorded. The watch glass was placed in a controlled environment (e.g., room temperature) or a desiccator to minimize external factors that might affect evaporation. The perfume was allowed to sit uncovered for a predetermined amount of time. After the designated time, the weight of the watch glass with the remaining perfume was recorded.

Stability Test

Procedure: The fragrance oil was placed in a glass bottle and stored at room temperature (around 20-25°C). It was observed after a specific period of time.

Sensory Test

Procedure: Three Panelists were gotten and asked to evaluate the fragrance oil based on intensity of smell. The results were recorded on a scale of 1-5.

Silage Test

Test Procedure: The fragrance oil was applied on a test subject. The perfume was allowed to settle for a few minutes in the enclosed room. The observer moved 1meter and 2meter away from the test subject. How far the scent travelled was recorded.

Adhesion Test

An adhesion test for oil-based perfumes typically assesses how well the perfume adheres to surfaces, such as skin or fabric. Here's a basic outline of how you can conduct such a test:

Test Procedure: A clean fabric was obtained. An amount of the fragrance oil was applied to the fabric. It was allowed to set for a couple of minutes. The fabric was then washed. The fabric scent was evaluated and results recorded.

RESULTS AND DISCUSSION

Results

Table 1: Result for Colour Evaluation

Oil-Based	**Fragrance Perfume**
Observation	**Inference**
A clear yellow colour	Pure oil perfume
Alcohol-Based	**Fragrance Oil**
Observation	Inference
Colourless	A pure alcohol based oil perfume

Table 2: Result for Odour Evaluation

Odour	Oil-Based	Alcohol-Based
Initial sniff	Floral scent	Stronger Floral scent
Middle note	Floral scent	Stronger Floral scent
Base note	Vanilla scent	Vanilla scent

Table 3: Result for pH Evaluation

	Ph	Inference
Oil-Based	5	Suitable for skin
Alcohol-Based	4	Suitable for skin

Table 4: Skin irritation test

	Oil-Based	Alcohol-Based	Inference
Immediate allergic reaction	Nil	Nil	Pleasant to the skin
Delayed allergic reaction	Nil	Nil	Pleasant to the skin

Viscosity Evaluation

The viscosity was evaluated and calculation stated below;

$$n_1 = n_2 \times \frac{P1 \times t1}{p2 \times t2}$$

Where;

n_1 = viscosity of liquid being measured

n_2 = viscosity of water

p_1 = density of liquid

p_2 = density of water

t_1 = time of flow of liquid

t_2 = time of flow of water

Where;

Density of water = 1

Time of flow of water = 20 seconds

Viscosity of water = 0.890

For Oil-Based

$$n_1 = 0.890 \times \frac{1.03 \times 54.42}{1 \times 20}$$
$$= 2.49$$

For Alcohol-Based

$$n_1 = 0.890 \times \frac{0.994 \times 6.61}{1 \times 20}$$
$$= 0.29$$

For Density Evaluation

The density was evaluated using a picnometer and results stated below;

$$P = \frac{w2 - w1}{v}$$

Where;

W_2 = weight of liquid + weight of empty picnometer

W_1 = weight of empty picnometer

V = volume of liquid.

Where;
W_1 = 13.06
V = 12ml

Table 5: Density Evaluation for Oil-Based

W_2	W_1	W_2-W_1	$\frac{w2-w1}{v}$
25.42	13.06	12.36	1.03
25.41	13.06	12.35	1.02
25.43	13.06	12.37	1.03
			Average = 1.03

Table 6: Density Evaluation for Alcohol-Based

W_2	W_1	W_2-W_1	$\frac{w2-w1}{v}$
25.00	13.06	11.94	0.995
25.00	13.06	11.94	0.995
24.95	13.06	11.89	0.991
			Average = 0.994

Spread ability Evaluation

$S = \frac{m \times l}{t}$

m = weight applied to upper glass slide

l = length moved by glass slide

t = time taken.

Where;

t = 10 minutes

m = 500grams

For Alcohol-Based

$S = 500g \times \frac{6cm}{10min} = 300gcm\ min^{-1}$

For 0il-Based

$S = 500g \times \frac{1}{10} = 50gcm\ min^{-1}$

Table 7: For Greasability Evaluation

The surface of skin was evaluated for shine or oiliness and how long it diminished at intervals and results was stated below;

Ingredient	5 minutes	10 minutes	15 minutes	30 minutes
Oil based	Highly greasy	Moderately greasy	Low greasy	Nil
Alcohol based	Low greasy	Nil	Nil	Nil

Table 8: For Stability Test

The oil fragrances were evaluated at room temperature (20°c - 25°c).

Temperature	Oil-Based	Alcohol-Based
Room temperature	Stable	Stable

Table 9: For Sensory Evaluation

Three (3) Panelist were used for the evaluation based on intensity of smell of the fragrance oil and results were recorded on the scale of 1-5

Subject	Oil-Based	Alcohol-Based
Panelist 1	3	4
Panelist 2	2	3
Panelist 3	3	4

Table 10: Sillage Test Evaluation

The fragrance oil was applied on a surface and the testers were asked to move away 1meter and 2 meter away. This was to access how far the scent traveled and results were recorded below;

Distance	Oil-Based	Alcohol-Based
1 meter	High scent	High scent
2 meter	Low scent	High scent

Table 11: Adhesion Test Evaluation

The fragrance oil was applied on a fabric and set for 5 minutes and the scent of fragrance on the fabric was evaluated after a wash cycle.

Oil-Based	Alcohol-Based
High scent	Low scent
High scent	Low scent

Table 12: Difference between Oil-Based and Alcohol Based fragrance oil

Quality Parameter	Oil-Based	Alcohol-Based
Colour	A clear yellow colour	Colourless
Odour	Floural scent on initial sniff, vanilla scent on a base note	Stronger floural scent on initial sniff, vanilla scent on base note
Ph	5	4
Skin irritation	Nil	Nil
Viscosity	2.49	0.29
Density	1.03	0.994
Spreadibility	50	300
Greasibility	Highly greasy	Less greasy
Stability (at room temp)	Stable	Stable
Sensory test (intensity on a scale of 1-5)	3	4
Sillage test	Low scent	High scent
Adhesion test	High adhesion	Lower adhesion

Table 12: Comparing Alcohol-Based and Oil-Based Perfumes in Terms of Spread

Property	Alcohol-Based Perfume	Oil-Based Perfume
Evaporation Rate	Fast (high volatility)	Slow (low volatility)
Scent Diffusion	Wide spread due to rapid evaporation	Limited spread, fragrance stays close to skin
Sillage (Projection)	High sillage, scent trail extends farther	Low sillage, more intimate scent experience
Longevity	Shorter-lived fragrance (due to faster evaporation)	Longer-lasting fragrance (due to slow absorption)
Skin Sensitivity	Can dry out skin, may cause irritation	More hydrating, gentler on skin

DISCUSSION

Perfume plays a significant role in human culture and society, offering benefits that extend beyond mere fragrance. Its importance can be examined from various perspectives, including its psychological, social, cultural, economic, and historical significance.

From the results obtained, the evaluation of the different fragrance oil produced reveals their differences and helps in preferential choices of consumers. Based on the colour evaluation it was seen that for both oil-based and alcohol-based fragrances they appeared clear. This implies high level of purity and stability of the fragrance oils. On the odour evaluation, the scents of both oil-based fragrance oil and alcohol-based fragrance oil were perceived and at initial sniff a floral scent was noted and the base indicated that both had a vanilla scent but for the alcohol-based fragrance oil the initial notes where more intense. Alcohol-based fragrance oils are often more intense at first application due to alcohol's volatility and its ability to disperse fragrance molecules more rapidly into the air.[9] Oil-based fragrances tend to release their scent more gradually, providing a longer-lasting but less intense fragrance compared to alcohol-based perfumes.[9]

Based on volatility and evaporation, alcohol is a highly volatile compound, which means it evaporates quickly. When an alcohol-based fragrance is applied to the skin, the alcohol evaporates almost immediately, carrying the fragrance molecules with it. This rapid evaporation results in a more intense initial "burst" of scent. In-contrast, oil-based fragrances have a slower evaporation rate because oils are less volatile. As a result, oil-based perfumes release their scent gradually over a longer period, creating a more subtle and longer-lasting experience, but the initial intensity is less.

Concentration and duration, alcohol-based perfumes are typically more concentrated than oil-based ones, which means they may contain higher levels of fragrance oils relative to the carrier alcohol. This contributes to a stronger initial scent. However, over time, the alcohol's quick evaporation means the fragrance can dissipate faster. Oil-based fragrances, while less intense at first, tend to last longer on the skin because the fragrance oils are absorbed slowly into the skin, allowing for a prolonged release of scent.

Skin Interaction, alcohol can dry out the skin slightly, which can cause the fragrance to "pop" or become more noticeable at first application. In contrast, oil-based fragrances tend to absorb into the skin more smoothly and slowly, resulting in a softer release of fragrance over time. This difference in how the skin interacts with the fragrance also influences the perceived intensity of the scent. Based on pH, the oil-based fragrance oil has a pH of 5 while the alcohol-based fragrance oil has a pH of 4. The pH of the skin typically ranges from 4.5 to 6, this implies its suitability on the skin.

Based on skin irritation evaluation, it was seen to not have any immediate or delayed allergic reactions on application this makes it suitable to be applied on skin.

Based on viscosity evaluation, the viscosity of oil-based perfumes is higher than that of alcohol-based perfumes due to the nature of the carrier substances used. Oils are denser and thicker than alcohol, which makes oil-based perfumes more viscous. In contrast, alcohol, being a liquid with low viscosity, allows alcohol-based perfumes to evaporate more quickly and disperse scent more immediately. Oil-based perfumes, on the other hand, release their fragrance more slowly, resulting in a subtler, longer-lasting scent.

Based on density evaluation, the density of alcohol-based fragrance oil was seen to be lower than that of oil-based fragrance oil. The lower density of alcohol-based fragrance oils, compared to oil-based perfumes, is due to the smaller molecular size and lighter weight of alcohol molecules. [11] The higher density of oil-based perfumes contributes to their longer-lasting fragrance and slower evaporation rate, which is preferred by those seeking a more enduring scent. [10]

Based on spread ability test, it was seen that alcohol-based fragrance oil had more spread than oil-based fragrance oil. Alcohol-based fragrance oils contain alcohol as the primary solvent (e.g., ethanol or isopropyl alcohol). Alcohol is a highly volatile substance, meaning it evaporates very quickly when applied to the skin or exposed to air. This quick evaporation carries the fragrance molecules away from the body, dispersing the scent over a larger area and creating a wider spread or sillage. Oil-based fragrance oils, on the other hand, are made

with thicker carrier oils (e.g., jojoba oil, coconut oil, or fractionated coconut oil). Oils are less volatile than alcohol, meaning they do not evaporate as quickly. Instead, the fragrance stays closer to the skin, which leads to a subtler, less widespread scent. The oil-based fragrances have a more intimate scent that lingers on the skin without spreading as broadly into the air.

Based on greasability test, alcohol-based fragrance oil was seen to be less greasy than oil-based fragrance oil. Greasiness in this context refers to the texture and residue left on the skin after applying the fragrance. Alcohol-based fragrances are less greasy because alcohol evaporates rapidly, leaving no residue on the skin.[11] In contrast, oil-based perfumes leave a greasier feeling due to the slow absorption and heavier, thicker oils used in their formulation.[10] Based on sensory test, they both had a high intensity scale sent but alcohol-based fragrance oil was higher.

Evaluation based on sillage test, at one meter the both scents where high but at 2 meters alcohol-based scent was higher compared to oil-based fragrance oil.

Evaluation based on adhesion test, after a wash cycle, the oil-based fragrance scent was noted to still be there compared to the alcohol-based fragrance oil.

CONCLUSION

This study successfully formulated and evaluated alcohol-based and oil-based fragrance oils containing rosemary and vanilla, demonstrating that both systems meet acceptable quality standards for cosmetic application. Both formulations were stable, non-irritant, and exhibited suitable pH values, confirming their compatibility with the skin.

Notable differences were observed in their performance characteristics. The alcohol-based formulation showed lower viscosity, higher spread ability, and stronger initial scent projection due to rapid evaporation, resulting in greater sillage but shorter longevity. In contrast, the oil-based formulation exhibited higher viscosity and density, reduced spread, and increased greasiness, leading to slower fragrance release, enhanced adhesion, and longer-lasting scent retention.

Hence, alcohol-based fragrances are more suitable for immediate scent impact and wider diffusion, whereas oil-based fragrances are preferable for prolonged effect and skin-friendly application. These findings emphasize the critical role of carrier systems in fragrance formulation and provide a basis for selecting appropriate perfume types based on desired performance and consumer preference.

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