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OLEOGELS FROM WATERMELON RIND EXTRACT AND ORANGE PEEL ESSENTIAL OIL FOR HAIR NUTRITION

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Abstract: Watermelon rind extract is rich in protein, citrulline, and lycopene, whereas orange peel essential oil contains vitamins A, C, and E. Both ingredients have demonstrated potential in preventing hair loss. This study aimed to develop an oleogel that combines these two components to address hair loss. The efficacy of the oleogel for promoting hair growth was evaluated in male DDY (Deutchland Denken Yonken) mice. The oleogel characteristics, including pH, viscosity, color, homogeneity, oil binding capacity, spreadability, and organoleptic evaluations, were assessed through physical quality tests. Organoleptic analysis was conducted with 30 respondents from IPB University to identify the most preferred oleogel formulation. The yield of watermelon rind extract was 28.88%, while the orange peel essential oil constituted 2% (v/w) of the formulation. The optimal oleogel contained 3% watermelon rind extract and 1% orange peel essential oil, resulting in 100% hair growth in the mice. All the formulations met the standard requirements for oleogels, with the most favored being Formula F3, which includes 1% watermelon rind extract and 3% orange peel essential oil. This research highlights the potential of watermelon rind extract and orange peel essential oils as effective nutrients for hair loss treatment.

Keywords: Hair loss nutrition, oleogel, orange peel, watermelon peel

Abstrak: Ekstrak kulit putih semangka kaya akan protein, sitrulin, dan likopen, sedangkan minyak asiri kulit jeruk mengandung vitamin A, C, dan E. Kedua bahan tersebut memiliki potensi untuk mencegah kerontokan rambut. Penelitian ini bertujuan membuat sediaan oleogel yang menggabungkan kedua bahan tersebut untuk mengatasi kerontokan rambut. Uji

efektivitas pertumbuhan rambut dilakukan pada mencit jantan (*Mus musculus*) *Deutchland Denken Yonken* (DDY), sedangkan karakteristik oleogel ditentukan dengan uji kualitas fisik, uji pH, viskositas, warna, homogenitas, kapasitas pengikatan minyak, daya sebar, dan organoleptik. Analisis organoleptik dilakukan kepada 30 responden mahasiswa Institut Pertanian Bogor (IPB) dengan mengidentifikasi sediaan yang paling disukai. Rendemen ekstrak kulit putih semangka yang dihasilkan sebesar 28,88%, sementara distilat minyak asiri kulit jeruk menghasilkan rendemen 2% (v/b). Sediaan oleogel yang memberikan hasil paling baik mengandung 3% ekstrak kulit putih semangka dan 1% minyak asiri kulit jeruk, yang menunjukkan pertumbuhan rambut 100% pada mencit. Semua sediaan memenuhi persyaratan oleogel, dengan formula yang paling disukai adalah F3 (mengandung 1% ekstrak kulit putih semangka dan 3% minyak asiri kulit jeruk). Penelitian ini menunjukkan potensi ekstrak kulit putih semangka dan minyak asiri kulit jeruk sebagai penutrisi rambut rontok.

Kata kunci: Kulit jeruk, kulit semangka, nutrisi rambut rontok, oleogel

INTRODUCTION

Hair is a valuable aspect of personal appearance, particularly for women. However, a survey by Research International revealed that approximately 45% of Indonesian women suffer from hair loss. Various factors can contribute to hair loss, including nutrient deficiencies that impair the oxygen supply to hair follicles (Kristiningrum, 2018). An adequate nutrient supply, particularly protein and citrulline, is crucial for optimal hair follicle function, promoting hair growth and maintaining hair strength and thickness (Guo & Katta, 2017).

Traditionally, hair care products such as shampoos and hair tonics are used to address hair loss. However, inappropriate selection of these products can lead to residue buildup, dryness, and scalp irritation (Srivastava *et al*. 2015). Many shampoos contain synthetic ingredients such as surfactants that strip away sebum, which is essential for moisture retention and scalp protection (Gubitosa *et al*. 2019). Modern cosmetic trends favor natural ingredients because of their perceived safety and effectiveness. Plants and fruits are increasingly being used as alternative raw materials in cosmetics (Dipahayu & Arifiyana, 2019). Among promising ingredients are watermelon rind and orange peel, both of which have shown potential as nutrients to combat hair loss.

Watermelon rinds are rich in alkaloids, flavonoids, saponins, tannins, and various vitamins and minerals, including vitamins A, B2, B6, E, C, protein, citrulline, and lycopene (Sumbayak & Diana, 2018). It has been reported to enhance hair growth at a concentration of 4% (Setiawan *et al*.

2018). Orange peels contain vitamin C, A, E, and B vitamins; phosphorus; calcium; flavonoids; and limonoids, comprising 7−7.6% of the peel, which can help prevent hair loss. Flavonoids play a critical role in this protective effect (Nurita *et al*. 2018), and vitamin C in orange peels has also been shown to be effective against hair loss (Wijaya & Nisyak, 2020). Watermelon rinds hold potential as ingredients in cosmetic formulations, particularly when combined with essential oils from orange peels.

According to the Central Statistics Agency, Indonesia's watermelon production in 2020 reached 523,335 tons, with waste comprising approximately 30% of the fruit (Oseni & Okoye, 2013). Additionally, the Ministry of Agriculture reported that in 2019, Indonesia produced 2.77 million tons of oranges, with outer shell waste (flavedo) accounting for 27% of the fruit (Mahato *et al.* 2018). Despite the significant amount of waste generated from watermelon and orange peels, their utilization remains suboptimal.

To date, there has been no research that combines watermelon rind extract and orange peel essential oils as hair nutrients. The question that needs to be answered from this research is whether the combination of these two ingredients is effective enough to serve as a hair nutrient. This study aims to evaluate the effectiveness of an oleogel formulated by combining these two ingredients in addressing hair loss.

METHOD

This study commenced with the extraction of watermelon rinds and the distillation of orange peel essential oils. The resulting watermelon rind extract and orange peel essential oil were incorporated into various oleogel formulations combined with additional additives. These formulations were then tested in mice to evaluate their effectiveness in promoting hair growth. The oleogels were characterized through a series of tests, including pH, viscosity, and physical assessments such as color and homogeneity. Further evaluations included oil binding capacity (OBC) tests, dispersion tests, and organoleptic assessments. Additionally, histopathological examinations were conducted to analyze the growth of hair follicles in the test animals.

Tools and Materials

This study utilized various tools, including a distillator (LSD-5 LABOAO), blender (Cosmos), pH meter (PH5S IONIX), vacuum evaporator

(EVP-100 Agrowindo), viscotester (RION VT-04F), ultra and refrigerated centrifuge (MIKRO 200R HETTICH), water bath (Memmert WTB15), maceration vessel, and glassware (IWAKI). The ingredients employed included watermelon rind sourced from fruit-cutting shop waste in Bogor, West Java, and orange peel obtained from squeezed orange shop waste in Bogor, West Java. The additional components used were olive oil (Beorganic), propylene glycol (Central Kimia), 70% ethanol (Central Kimia), beeswax, and hydroxypropyl methylcellulose (HPMC) (Central Kimia).

Watermelon White Peel Extraction

A total of 150 g of watermelon rind powder was placed into a maceration vessel, and 1 liter of 70% ethanol was added. Maceration was performed for 3 days (3 × 24 hours) with stirring three times daily. The resulting mixture was filtered through filter paper, and the filtrate was then evaporated via a vacuum evaporator at 50°C until a viscous extract was obtained (Anggraeni *et al.* 2019).

Distillation of Orange Peel Essential Oil

A total of 1 kg of dry squeezed orange peel alone was weighed and placed into a distillation flask. Water was added, and heating commenced once steam was generated. Distillation was conducted for 4 to 6 hours, with the distillate collected in a beaker. The resulting oil–water mixture was then separated via a separating funnel. The oil was transferred to sample bottles and stored in a refrigerated environment at 6−7°C (Muhtadin *et al*. 2013).

Mixing Oleogel Extracts and Formulations

One milliliter of olive oil and three grams of beeswax were combined in a beaker and heated in a water bath at 70°C. One gram of hydroxypropyl methylcellulose (HPMC) and propylene glycol were subsequently added, and the mixture was mixed until it was homogeneous. The temperature was then

Table 1. Oleogel Dosage formulation

Material	Formula			
	F1	F2	F3	Negative Control (-)
Watermelon white peel (g)	3	2	1	-
Orange peel asiri oil (mL)	1	2	3	-
Beeswax (g)	3	3	3	3
Propylene glycol (ml)	1	1	1	1
Olive oil (mL)	1	1	1	1
HPMC (g)	1	1	1	1

reduced to 40°C, and the watermelon rind extract and orange peel essential oil were incorporated according to the formulations detailed in Table 1. The mixture was stirred for 5 min until fully homogeneous (Uronnachi *et al.* 2022).

Evaluation of hair growth

Hair growth was assessed in vivo in male Deutschland Denken Yonken (DDY) mice (*Mus musculus*) that had been acclimatized for 2 weeks with ad libitum access to food and water. Hair removal was performed via the application of a depilation cream (Veet) to an area of approximately 3 × 3 cm on the mice under stage III anesthesia. A total of 18 DDY mice were divided into six groups, each consisting of three mice. The formulations tested included F1, F2, F3, a negative control (-), a positive control (+), and a group without treatment. The samples were applied to the backs of the mice at a dose of 1 g per test once daily in the afternoon for 3 weeks. Hair growth was monitored and recorded on the 1st, 7th, 14th, and 21st days. Additionally, hair follicle observations were conducted by preparing histopathological slides after the mice were euthanized (Surya *et al*. 2022). Euthanasia was performed via humane techniques, specifically cervical dislocation, while the animals were still under anesthesia following blood collection (Santoso, 2016; Isbago, 1992).

Characterization of the oleogel

Physical quality test of the oleogel

The oleogel was subjected to weekly physical quality assessments at both room temperature (28−30°C) and refrigeration (6−7°C) over a period of 4 weeks. The physical quality tests included pH measurements using pH meters, viscosity assessments with viscotesters, color evaluations using colorimeters, and homogeneity checks by applying the oleogel to transparent glass and observing its consistency (Gunawan, 2020).

Oleogel Oil-Binding Capacity Test (OBC)

The oil-binding capacity of the oleogels was assessed using the centrifugation method. One gram of oleogel sample was placed into a 1.5 mL centrifugation vial. The sample was then centrifuged at 5000 rpm for 30 minutes to allow for oil separation. The remaining oleogel in the vial was weighed (m2) (Trirahayu *et al.* 2018). The oil loss content was calculated by comparing the weight of the released oil to the initial weight of the oleogel, using the formula: Oil loss (%) = $(m_2 - m_1) \times 100\%$.

Spread Force Test

A total of 1 g of oleogel was applied to a glass slide, and another glass slide was placed on top to spread the sample. The initial diameter of the spread was measured. One hundred grams of weight was subsequently placed on the top glass slide, and after 5 minutes, the diameter of the oleogel spread was recorded (Kenechukwu *et al.* 2017). The dispersion was calculated using the following formula:

$$Dispersion\ force = \frac{Increase\ in\ diameter}{Initial\ diameter} x\ 100\%$$

Organoleptic test

Four oleogel formulations, along with one positive control (hair tonic), were subjected to organoleptic testing with 30 students from IPB University. Organoleptic evaluation, a hedonic test, was conducted to assess product preference on the basis of parameters such as color, aroma, viscosity, and texture of the oleogel.

Data analysis

The experimental design was a completely randomized design comprising 6 treatments with 3 replications each. The data collected from the tests were analyzed using ANOVA with SPSS and RStudio software. If significant differences were detected, post hoc analysis was conducted using Duncan's multiple range tests, with the significance level set at 95%.

RESULTS AND DISCUSSION

Watermelon White Peel Extract

The extraction of watermelon white peels was conducted via the maceration method, a cold extraction technique involving the soaking of material to extract bioactive compounds. This method is preferred for its simplicity, cost-effectiveness, and efficiency. The process yielded a thick, reddish-brown extract weighing 260 grams from 900 grams of finely ground watermelon peel powder, resulting in a 28.88% yield. These findings demonstrate that maceration is an effective technique for achieving high yields from plant materials.

Orange Peel Asiri Oil

The selected orange peel used is from the *Citrus sinensis* variety, which is specifically sourced from squeezed orange production waste in Bogor, West Java. The quality of distilled orange peels directly impacts the quality of the essential oils produced (Pratiwi & Utami, 2018). Therefore, only fresh orange peels with a bright yellow–green color were selected. The distillation process yielded

120 mL of essential oil from 6 kg of orange peel, which was distilled over 4−6 hours, resulting in an essential oil content of 2% (v/w). The resulting essential oil is cloudy white, with a refreshing aroma characteristic of *Citrus sinensis*, meeting the quality standards outlined in ISO 855-2003.

Formulation and Prototype of the Oleogel

Oleogels are distinguished by several advantageous properties, including mucoadhesion, thixotropy, and ease of spreadability. Oleogels, which are composed of lipophilic fluids gelled with appropriate gelling agents, are versatile in their ability to deliver both lipophilic substances, such as essential oils, and hydrophilic drugs (Tomczykowa *et al.* 2018). The oleogel was prepared in three different formulations, along with negative and positive controls, for comparison. The oleogel contains beeswax, olive oil, hydroxypropyl methylcellulose (HPMC), and propylene glycol. Beeswax acts as an organogelator and is noted for its properties as a hair nourisher (Uronnachi *et al*. 2022). HPMC and propylene glycol function as gelling agents and preservatives, respectively, making them suitable additives for formulation. Olive oil is beneficial for dry skin (Oktavia *et al*. 2021). Figure 1 displays the oleogels from formulas 1−3 and the negative control. Formulas 1−3 include orange peel essential oil, watermelon white peel extract, beeswax, olive oil, propylene glycol, and HPMC at specific ratios, as detailed in Table 1. In contrast, the negative control (formula (4)) contained all the additives except watermelon white peel extract and orange peel essential oil, which consisted of only beeswax, olive oil, propylene glycol, and HPMC.

Results of Hair Growth in the Test Animals

The results of hair length and hair density evaluations illustrate the ability of an animal's body to grow hair on its own (Uronnachi *et al*. 2022). Hair growth in vivo was evaluated in Deutschland Denken Yonken (DDY) strain mice following ethical approval (Approval Number: 080/KEH/SKE/VIII/2023). The evaluation focused on two parameters: the observation of the hair growth area and histopathological analysis. Hair growth was monitored on days 1, 7, 14, and 21 (referred to as D1, D7, D14, and D21). Figure 2 shows the hair growth of the mice observed on day 21, while Figure 3 presents weekly hair growth data.

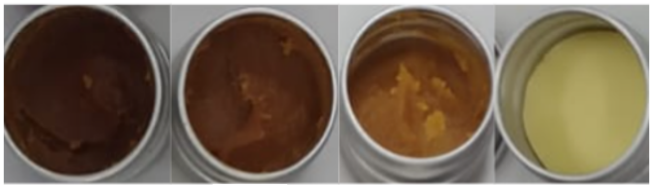


Figure 1. Display of the oleogel

Figure 2. D21 mouse hair growth

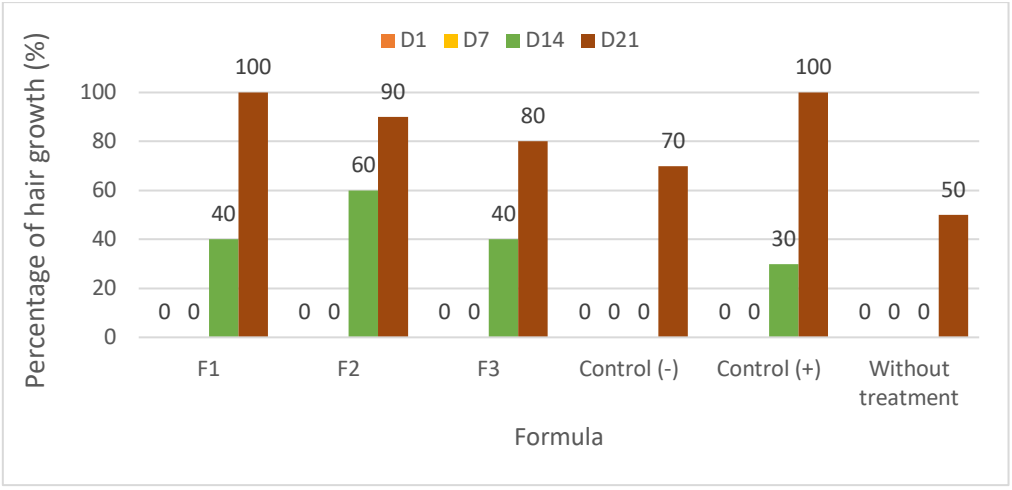


Figure 3. Graph of hair growth results of test animals in each treatment

As shown in Figure 3, no hair growth was observed on the 1st day across all the treatments. However, new hair growth was noted on the 14th day in the F1, F2, and F3 treatments and the positive control (+). The inclusion of watermelon peel extract and orange peel essential oil in formulas F1, F2, and F3 had a significant effect compared with the negative control, which did not include these ingredients. By the 21st day, untreated mice exhibited 50% hair growth, whereas the hair growth of the mice treated with the formulations exceeded 50%. Formula F1 had the best results among the treatments on the 21st day and outperformed the positive control (+) on the 14th day.

The effectiveness of hair growth was further evaluated through

histopathological examination to assess hair follicle development in mice. Figure 4 shows that compared with the other treatments, F1 and the positive control (+) resulted in a more substantial increase in the number of hair follicles. This increase in follicle count correlates with the observed percentage of hair growth.

The results of the histopathological analysis, as indicated by ANOVA, revealed significant differences in hair follicle growth responses among the various treatments. To identify which treatments resulted in significant differences, Duncan's post hoc test was conducted, and the findings are illustrated in Figure 5. The results of the Duncan test revealed that both F1 and the positive control (+) resulted in similar outcomes in terms of hair follicle growth, with both providing the best results because their average hair follicle growth was greater than that of the other formulas. Formula F1, which contains 3% watermelon peel extract and 1% orange peel essential oil, demonstrated that the inclusion of watermelon rind extract and orange peel essential oil significantly influences hair growth. Notably, the optimal treatment involves a higher concentration of watermelon peel extract than of orange peel essential oil.

Several studies have investigated the effects of orange peel oil on hair growth. Orange peel oil, like other citrus oils, contains antioxidants and vitamin C, which can stimulate blood circulation to hair follicles, improve scalp health, and promote hair growth (Namdev and Kundlik, 2024). According to research conducted by Erukainure *et al*. (2016), orange peel has the ability to nourish hair and mitigate hair loss, primarily because of its high vitamin C content. This finding underscores the potential of orange peel as a beneficial ingredient in hair care formulations, leveraging its nutritional properties to support hair health and prevent hair thinning.

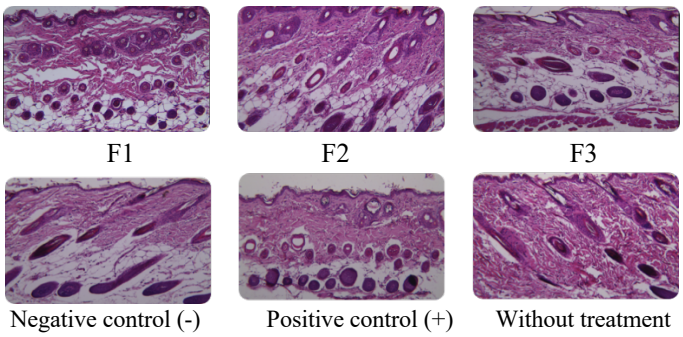


Figure 4. Histopathological test results for each formula

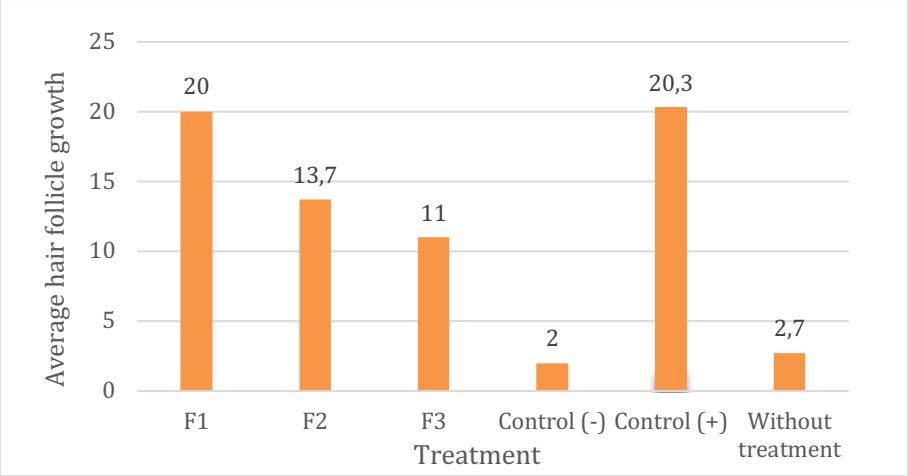


Figure 5. Graph of the results of hair follicle growth in test animals

Watermelon rind contains citrulline, an amino acid renowned for its antioxidant properties, which may contribute to improved scalp health and enhanced blood circulation. Additionally, watermelon rind extract has demonstrated promising results in inhibiting carbohydrate-hydrolyzing enzymes, suggesting its potential benefits in fields such as skin and hair care. This potential is attributed to the high phenolic content and robust antioxidant activity of rinds (Rimando and Perkins-Veazie, 2015). Citrulline, which is found in the white rind of watermelon, contains beneficial compounds that may help reduce hair loss. These include vitamin A, which supports hair cell growth; vitamin C, which serves as an antioxidant; vitamin E, which aids in repairing damaged hair follicles; and alkaloids and triterpenoids, which have antibacterial properties (Gustianeldi & Minerva, 2021).

Characteristics of the Oleogel

Physical Analysis

Physical quality testing of oleogels involves evaluations of their physical form, pH, viscosity, color, and homogeneity. pH is a crucial physicochemical parameter for topical oleogels, as it affects the effectiveness and stability of active substances, formulation stability, and skin comfort during use. The pH test results, obtained at both room temperature and refrigeration temperature (-4°C to 6°C) over a 28-day period, are presented in Figure 6.

The pH test results indicate that all three formulas and the negative control (-) have appropriate pH values, meeting the requirements for topical oleogels, which

should be between 4 and 8. Over the 28-day observation period, the pH values of each oleogel, whether stored at room temperature (Figure 6a) or refrigeration temperature (Figure 6b), remained stable, showing no significant increase or decrease. Specifically, the pH values for oleogels F1, F2, and F3 ranged from 6–6.5, whereas those of the negative control (-) ranged from 6.9–7.0. According to the Indonesian National Standard (SNI), the pH of the scalp ranges from 3–7. An oleogel with too acidic a pH can cause skin irritation, whereas an oleogel that is too alkaline may lead to flaky skin. The ANOVA results yielded a significant value of 0.607, greater than 0.05, indicating that the storage conditions (room temperature vs. refrigeration) do not significantly affect the pH values. Furthermore, the significance value of 0.421, which was also greater than 0.05, suggested that the 28-day storage period did not significantly impact the pH value.

Viscosity is a measure of a liquid's thickness, indicating how easily it flows and how resistant it is to changes in shape or movement. A lower viscosity signifies easier flow. The viscosity testing results for all three formulas and the negative control (-) met the criteria for good viscosity. The viscosity values for oleogel formulas F1, F2, and F3 range from 3000 to 3500 cP, whereas the negative control (-) has viscosity values ranging from 2300 to 2500 cP. These results comply with the SNI 16-4399-1996 standard, which specifies a viscosity range of 2000 to 50,000 cP.

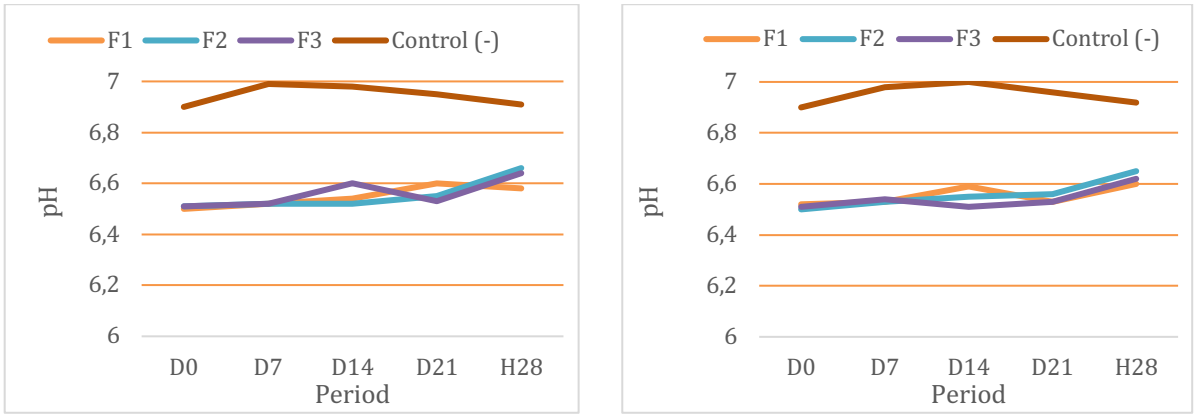


Figure 6. Graph of the pH testing results of the oleogel (a) at room temperature and (b) at refrigeration temperatures (-4°C to 6°C)

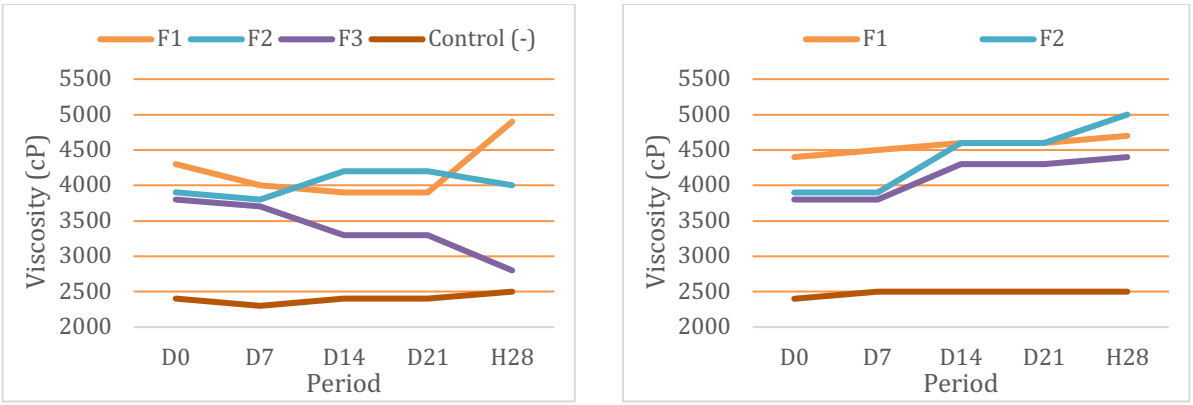


Figure 7. Graph of the viscosity testing results of the oleogel (a) at room temperature and (b) at refrigeration temperatures (-4°C to 6°C)

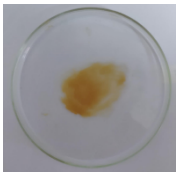
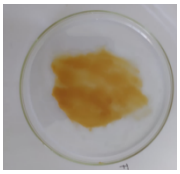
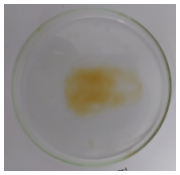
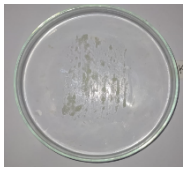
Throughout the 28-day observation period, the viscosity values of each oleogel stored at refrigeration temperature (Figure 7b) remained relatively stable, whereas those stored at room temperature (Figure 7a) fluctuated. An ANOVA yielded a significance value of 0.055, which is greater than 0.05, indicating that storage conditions (room temperature vs. refrigeration) do not significantly affect oleogel viscosity. Additionally, a value of 0.421, which is also greater than 0.05, suggests that the 28-day storage period does not significantly impact the viscosity. Color is another important physicochemical parameter for tropical oleogels, as it affects formulation stability, active substance stability, and consumer appeal. The color testing results for each formula and the negative control are detailed in Table 2.

Table 2. Color Testing of the Oleogel

Formula	L	a	B	Color	Color Description
F1	11.27 ± 0.35	10.87 ± 0.70	38.07 ± 0.35		*Dark brown*
F2	25.87 ± 0.32	19.90 ± 0.10	31.17 ± 0.55		*Brown*
F3	35.80 ± 0.26	10.03 ± 0.81	39.13 ± 0.40		*Light brown*
Negative control (-)	67.77 ± 0.55	9.47 ± 0.50	33.57 ± 0.60		*Cream*

Explanation: L = brightness level of color (value range 0–100 (black–white)); a = degree coordinate; b = reflected light.

Table 3. Results of the Homogeneity Test for Oleogel

Formula 1	Formula 2	Formula 3	Negative control (-)
			
Homogeneous	Homogeneous	Homogeneous	Homogeneous

The color of the oleogel is described using the CIELab color model, which includes the attributes 'L', 'a', and 'b'. The 'L' value indicates the brightness level of the oleogel's color. The 'a' value represents the degree of reflection of light that produces chromatic colors between red and green; a positive 'a' value indicates a greater degree of redness. The 'b' value represents the degree of reflection of light that produces chromatic colors between blue and yellow; a positive 'b' value indicates a higher degree of yellowness (Anita, 2019). The 'L' values indicate that the brightness level of the oleogel color ranges from cream to dark brown, specifically between 11.27 and 67.77.

The oleogel also underwent homogeneity testing to assess its uniformity. The oleogel was evaluated on the basis of criteria that require the absence of coarse grains or unevenly mixed materials. The results of the homogeneity test for the oleogel are detailed in Table 3.

The oleogels from each formula met the homogeneity requirements throughout the 28-day storage period, indicating that the oleogel remained uniform and that no coarse grains were observed on the glass slide (Anggraeni *et al.* 2019). These homogeneity requirements are intended to ensure an even distribution of active ingredients within the gel and to confirm that the gel does not cause irritation when applied to the skin.

Oil Binding Capacity (OBC)

The oil binding capacity test is designed to measure the amount of oil released from the oleogel, which indicates its capacity to bind oil. A stable oleogel with optimal mechanical properties is characterized by a low oil loss content (Patel *et al*. 2018). In this study, Formula 1 (Figure 8) demonstrated the best performance in terms of the oil

binding capacity, with an oil loss content of 14.6%, surpassing other variations. An ANOVA test was conducted to support these findings, yielding a significance value of 0.00, which indicates significant differences in the oil binding capacity among the formulas. Further analysis revealed that all the formulas exhibited varying oil binding capacities, with the highest capacity observed in the negative control (-).

Spreadability

The spreadability test of oleogels is designed to assess the ability of a gel to spread when applied to the skin. The measurement results indicate that the spread diameters of oleogels from Formulas 1, 2, and 3 and the negative control (-) are 5.57 cm, 6.53 cm, 6.90 cm, and 5.07 cm, respectively (Figure 9). All the formulas meet the criteria for good spreadability, which ranges from 5–7 cm (Sayuti, 2015).

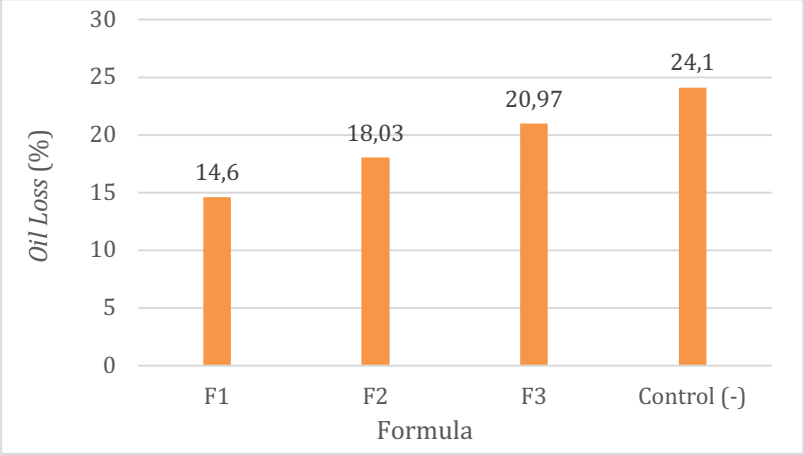


Figure 8. Results of the oil binding capacity of the oleogels

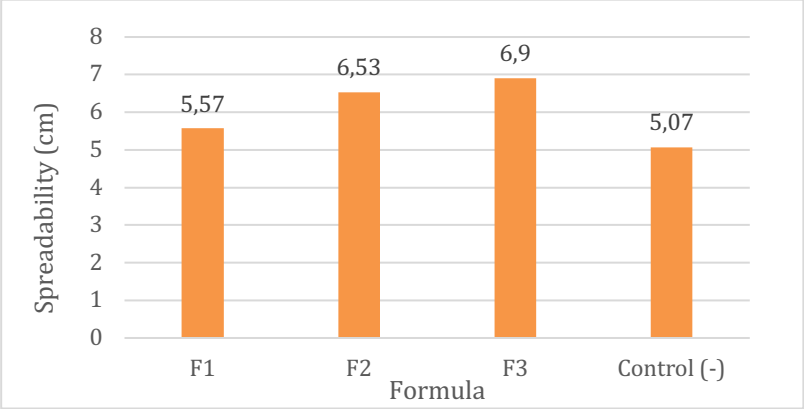


Figure 9. Graph of the spreadability testing results of the oleogels

Table 4. Hedonic Evaluation of Oleogel Formulations

Formula	Average			
	Color	**Scent**	**Viscosity**	**Texture**
F1	$2.70^{a} \pm 1.06$	$2.60^{c} \pm 0.81$	$2.83^{a} \pm 0.70$	$3.03^{a} \pm 0.76$
F2	$2.80^{a} \pm 0.92$	$2.60^{c} \pm 0.81$	$2.90^{a} \pm 0.61$	$3.00^{a} \pm 0.69$
F3	$3.07^{a} \pm 0.78$	$3.13^{b} \pm 0.78$	$2.60^{a} \pm 0.50$	$2.90^{a} \pm 0.66$
Control -	$2.87^{a} \pm 1.07$	$2.07^{d} \pm 1.01$	$2.10^{b} \pm 0.80$	$1.97^{b} \pm 0.85$
Control +	$3.20^{a} \pm 0.85$	$3.60^{a} \pm 0.67$	$2.63^{a} \pm 1.03$	$3.03^{a} \pm 0.81$

Figure 9 shows that Formula 3 is more widely spread than F1, F2, and the negative control (-) because of the greater amount of essential oil used in F3. An ANOVA test was conducted to support these findings, yielding a significance value of 0.00, which indicates significant differences in spreadability among the formulas. Further analysis confirmed that all the formulas differed in spreadability, with F3 showing the greatest spreadability.

Organoleptic test

Organoleptic testing of oleogels, which is based on panelist preferences, can influence the assessment of product quality. This testing involves hedonic evaluation, which should be based on the perceptions of the panelists, as it helps determine the quality of a product (Putriana & Aminah, 2018). Hedonic testing involves the evaluation of all the research findings by 30 panellists, consisting of 20 females and 10 males aged between 18 and 22 years. The panelists subsequently provided scores for the oleogels (Table 4).

On the basis of the test results shown in Table 4, the panelists preferred F1 and F2 for the texture parameter. For the color and aroma parameters, the panelists preferred F3. On average, the panelists did not prefer the negative control (-), whereas they preferred the positive control (+) for the color, aroma, and texture parameters. Based on |these results, the oleogel most preferred by the panelists was F3 (containing 1% watermelon peel extract and 3% orange peel essential oil). However, this preference was not as high as that of the positive control. Additionally, the determination of the best prototype is carried out through a scoring system calculation. A significance value of > 0.05 was obtained from the statistical analysis, indicating that there was no significant difference in the results. These findings suggest that a formula with a relatively high essential oil content is preferred.

CONCLUSION

Research has demonstrated that oleogels formulated with watermelon peel extract and orange peel essential oil effectively promote hair regrowth, with the most effective formulation being F1, which contains 3% watermelon peel extract and 1% orange peel essential oil. The physical qualities of all the oleogel formulations met the requirements of the Indonesian National Standard No. 06–2588, indicating appropriate pH, viscosity, homogeneity, and spreadability for hair care applications. Additionally, the oil binding capacity test confirmed the strength and stability of the oleogel, with F1 showing the best stability and the lowest oil loss content at 14.6%. Sensory evaluations revealed that while F3, containing 1% watermelon peel extract and 3% orange peel essential oil, was the most preferred by the panelists, its overall preference did not surpass that of the positive control.

This research represents the beginning of the development of hair nutrients derived from natural materials that were originally trash. Although this study has several limitations, including the subjective nature of the sensory evaluation and the concentration limitations of the oleogel used, it can provide initial information regarding the properties and uses of these 2 materials. Further research should explore various formulations, conduct long-term stability tests, and expand the sensory evaluation panel so that this oleogel can be used commercially as a hair care product.

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