Research Article
Sciences of Pharmacy

Formulation and Stability Evaluation of Red Dragon Fruit (*Hylocereus polyrhizus*) Extract Gel

Novi Febrianti, Lina Widyastuti, Septiana Saputri, Lalu Muhammad Irham

[The author informations are in the declarations section. This article is published by ETFLIN in Sciences of Pharmacy, Volume 4, Issue 4, 2025, Page 239-250. DOI 10.58920/sciphar0404379]

Received: 09 June 2025
Revised: 15 August 2025
Accepted: 15 October 2025
Published: 01 November 2025

Editor: Garnadi Jafar

Keywords: Red dragon fruit, Hylocereus polyrhizus, Carbopol 940, Triethanolamine, Gel, Antioxidant, Antiaging.

Abstract: Red dragon fruit (*Hylocereus polyrhizus*) is known for its strong antioxidant properties and potential anti-aging effects. To enhance its benefits and improve usability, this fruit extract was formulated into a gel preparation. This study aimed to determine the optimal proportions of Carbopol 940 and triethanolamine (TEA) to obtain a gel with desirable physical characteristics. The flesh of red dragon fruit was juiced and concentrated to produce an 8% extract. Three formulations were prepared with varying ratios of Carbopol 940 to TEA: 0.5%:0.3% (F1), 1.2%:0.7% (F2), and 2%:1.2% (F3). The gels were evaluated for physical properties, antioxidant activity, and antibacterial activity. The most promising formula was subjected to stability testing for three cycles under different temperature conditions: cold (3°C), room temperature (27°C), and climatic chamber (40°C, 75% RH). Results showed that formula F2 exhibited a characteristic red color, clear appearance, distinctive oleum rosae aroma, moderately thick and homogeneous consistency, viscosity of 3112.47 ± 177.90 cps, spreading diameter of 5.20 ± 0.20 cm, adhesion time of 18.45 ± 0.89 s, and pH of 5.33 ± 0.02. No significant changes were observed after the stability testing ($p > 0.05$), indicating that the formulation remained stable under all temperature conditions. F2 also showed higher antioxidant activity than F1 and better antibacterial properties than F3. Its stability and bioactivity support its potential as a promising natural cosmeceutical formulation.

Introduction

Red dragon fruit (*Hylocereus polyrhizus*) is widely recognized for its potent antioxidant activity, attributed to its rich composition of bioactive compounds. Among these, phenolic compounds, flavonoids, ascorbic acid (vitamin C), and betacyanin are the major contributors to its antioxidant effects (1-3). Phenolics and flavonoids act by neutralizing free radicals and reducing oxidative cellular damage, thereby playing a crucial role in protecting the body against chronic diseases and delaying the aging process. Ascorbic acid enhances this protective effect as a water-soluble antioxidant that regenerates other antioxidants and supports collagen synthesis, which is vital for skin health. Betacyanin, a natural red-violet pigment abundant in red dragon fruit, exhibits particularly strong antioxidant capacity (3, 4). Moreover, phenolic compounds, flavonoids, and ascorbic acid demonstrate notable antibacterial activity.

Given these bioactivities, red dragon fruit extract (RDFE) holds significant potential for applications in the cosmetic and beauty industry. Its antioxidant-rich profile can protect skin cells from environmental stress, reduce visible signs of aging such as wrinkles and fine lines, and promote a healthier, more radiant complexion. Additionally, the natural pigmentation from betacyanin may serve as a safe and beneficial colorant in topical formulations. Therefore, RDFE represents a valuable ingredient for developing innovative, plant-based skincare products that meet the growing consumer demand for natural and effective cosmeceutical solutions.

Red dragon fruit possesses versatile properties that allow its incorporation into a wide range of beauty formulations. Among these, gel-based products stand out due to their pleasant texture and user-friendly characteristics (5). Gels are highly favored in cosmetics because they are lightweight, easily absorbed, and can be removed without leaving sticky or oily residues. These qualities make them particularly suitable for individuals with oily or combination skin types seeking effective yet comfortable skincare solutions (6).

The preparation of gel cosmetics typically involves a gelling agent that provides a semi-solid, jelly-like consistency (7). Common gelling agents, such as Carbopol or xanthan gum, help stabilize the formulation and ensure uniform distribution of active ingredients like RDFE. An alkalizing agent, such as triethanolamine (TEA), is often added to neutralize the gelling agent, promote gel formation, and adjust the pH for skin compatibility (8). Together, these components produce a stable, aesthetically pleasing gel capable of effectively delivering the antioxidant and anti-aging benefits of red dragon fruit extract.

Carbopol is acidic, with a pH range of 2.5–4.0, while TEA is alkaline, with a pH around 10.5. When used individually, Carbopol 940 cannot form a gel and may cause skin irritation, whereas TEA alone may lead to skin dryness. Therefore, combining Carbopol 940 with TEA is essential to neutralize acidity, adjust the pH to a safe level, and yield a stable gel suitable for topical use (9). Optimal concentrations of Carbopol 940 (0.81%) and TEA (0.58%) were previously reported in ethanol extracts of *Tithonia diversifolia* leaves (10). Building on this, our study formulated various combinations of Carbopol 940 and TEA to develop an effective RDFE gel with minimal adverse effects.

The physical properties of the gels were evaluated using organoleptic parameters, viscosity, spreading diameter, adhesion time, and pH, along with physical stability testing. These assessments aimed to identify the optimal formulation with desirable texture, consistency, and stability during storage.

Table 1. Composition of red dragon fruit extract gel formulations.

Material	Composition (%w/w)			Function of Material
	F1	F2	F3	
Red dragon fruit extract	8	8	8	Active ingredient
Carbopol 940	**0.5**	**1.2**	**2.0**	**Gelling agent**
TEA	**0.3**	**0.7**	**1.2**	**Alkalizing agent**
Glycerin	14	14	14	Humectant
Methyl Paraben	0.1	0.1	0.1	Preservative
Oleum rossae	q.s	q.s	q.s	Fragrance
Aquadest ad	100	100	100	Solvent

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively.

Experimental Section

Materials

The red dragon fruits used in this study were obtained from the Wonoroto Dragon Fruit Tourism Garden, Sanden Sub-district, Bantul Regency, Daerah Istimewa Yogyakarta Province, Indonesia. To ensure accurate botanical identification, the plant specimens were examined and verified at the Biology Laboratory, Faculty of Applied Science and Technology (Fakultas Sains dan Teknologi Terapan), Universitas Ahmad Dahlan, Yogyakarta.

In addition to the red dragon fruit extract, several materials were employed in the gel formulation, including Carbopol 940 as the gelling agent, triethanolamine (TEA) as the alkalizing agent, glycerin as a humectant, methyl paraben as a preservative, purified water (aquadest) as the solvent, and oleum rosae (rose oil) as the fragrance. Carbopol 940, TEA, glycerin, and methyl paraben were purchased in pharmaceutical grade from PT Bratachem (Indonesia). All components were carefully selected to produce a stable, effective, and aesthetically pleasing gel formulation suitable for topical application.

Red Dragon Fruit Extract (RDFE) Preparation

A total of 1.260 kg of fresh red dragon fruit was weighed and thoroughly washed under running water to remove surface impurities. The fruit was then cut into four equal sections, manually peeled to separate the skin, and the flesh was collected. The collected flesh was weighed and processed using a juicer (Philips HR 1811/71) to obtain the juice. The juice was transferred into a porcelain dish and concentrated on a water bath (infusion pan) maintained at 70–80 °C for approximately five h until a viscous consistency was achieved. The resulting concentrated product was designated as the extract. The extract was stored in a glass beaker covered with aluminum foil and kept under refrigeration until further use.

Gel Formulation

Carbopol 940 was dispersed in 50 g of distilled water and allowed to hydrate for 24 h. Methyl paraben was dissolved in glycerin and stirred until homogeneous (Mixture I). Mixture I was then combined with the pre-dispersed Carbopol 940 to form Mixture II. Triethanolamine (TEA) was added to Mixture II and stirred until uniform (Mixture III). Subsequently, 8 g of red dragon fruit extract, oleum rosae, and the remaining distilled water were incorporated into Mixture III and stirred until homogeneous. The pH of the final mixture was then measured. The composition of the gel formulations is presented in **Table 1**. The prepared gels were transferred into gel pots lined with aluminum foil and stored in a refrigerator for preservation.

Organoleptic Test

The resulting RDFE gel was observed for its odor, color, and consistency (11).

Homogeneity Test

A total of 0.5 g of the RDFE gel was placed on a glass slide and covered with another slide. The gel preparation was considered homogeneous if no coarse particles were observed under visual inspection (12). Visual observation was also performed by applying the gel onto a glass plate to assess color uniformity (11).

Spread Diameter Test

A total of 0.5 g of RDFE gel was placed at the center of a round glass plate lined with graph paper, and another glass plate was placed on top for 1 min. Sequential loads of 50 g, 100 g, 150 g, 200 g, and 250 g were then applied, each for 1 min (13). The diameters of the spread were measured from four directions, and the average diameter was calculated. According to reference (14), a gel preparation is considered to have good spreadability if the average spreading diameter ranges between 5 and 7 cm.

Viscosity Test

The viscosity of the gel was measured using a Rheosys Micro VR viscometer (Rheosys Merlin VR with Rheosys Micra software) equipped with a 30 mm parallel plate spindle and a 1.0 mm gap. Approximately 50 mg of the sample was placed on the plate and compressed to maintain a 1 mm spacing. According to reference (15), a gel is considered to have an acceptable viscosity if it falls within the range of 2000–4000 cps. The measurement parameters were set as detailed in **Table 2**.

Adhesion Time Test

Approximately 50 mg of RDFE gel was placed on a glass slide and evenly spread using a plastic spatula. Another slide was placed on top of it, followed by the application of a 1 kg load for 5 min. Afterward, an 80 g load was released, and the time

Table 2. Parameter of Rheosys Micro viscosimeter.

Parameter	Value
Start speed	7 rpm
End speed	50 rpm
Steps	8
Direction	Up
Delay time	20 second
Integration	20 second
Log/Lin	Linear
Setting °C	25°C
Z shear	10

required for the two slides to separate was recorded. According to reference (16), a gel is considered to have good adhesion if the separation time exceeds 4 s.

pH Test

The semi-solid pH meter (Ohaus) was calibrated before use for measuring the pH of the gel. The pH meter was then dipped into the RDFE gel that had been made and the pH value was recorded on the pH meter. In semi-solid preparations, the pH is adjusted to the pH of the skin so that the safe range for application on the skin is between 4.5 and 6.5 (17).

Antioxidant Test

The free radical scavenging activity of different RDFE gel formulations was evaluated using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay (Merck, Germany). Various concentrations of the gel (100, 150, 200, 250, and 300 ppm) were prepared in 95% methanol (Merck, Germany), and 50 µL of each solution was transferred into a 10 mL test tube. Subsequently, 4 mL of 0.1 mM DPPH solution in 95% methanol was added, and the mixture was vortexed and incubated in the dark at room temperature for 30 min. The absorbance was then measured at 515 nm. The procedure was performed according to reference (18) with slight modifications. Ascorbic acid, prepared using the same method, served as the positive control. The DPPH scavenging activity was calculated using the equation described by Nurliyana R. *et al*. (19).

Antibacterial Activity

Bacterial Culture and Activation

Preparation of Mueller Hinton Agar (MHA) Solid Medium (Oxoid, Indonesia): The MHA solid medium was prepared by dissolving 38 g of MHA powder in 1 L of distilled water in an Erlenmeyer flask. The mixture was heated and stirred continuously with a glass rod on a hot plate until all solid particles were completely dissolved. The flask was then sealed with high-temperature sealing film and sterilized in an autoclave at 121 °C for 15 min. While still hot, the medium was poured evenly into 90 mm glass Petri dishes and allowed to cool and solidify at room temperature to form MHA plates.

Preparation of Nutrient Agar (NA) Medium (Oxoid, Indonesia): The NA medium was prepared by dissolving 2 g of agar powder in 100 mL of distilled water in a dry conical flask. The mixture was heated and stirred on a hot plate until completely dissolved. The flask was sealed with high-temperature sealing film and sterilized in an autoclave at 121 °C for 15 min. Subsequently, 3 mL of the sterilized medium was transferred into test tubes, positioned at an angle of 30–45 °C, and allowed to solidify. The slanted agar tubes were then stored in a refrigerator until use.

Preparation of Mc. Farland Standard

A standard turbidity solution was prepared by mixing 9.95 mL of 1% sulfuric acid solution (Merck, Germany) with 0.05 mL of 1.175% barium chloride solution (Merck, Germany) in a test tube, followed by thorough mixing until homogeneous. When the turbidity of the test bacterial suspension matched that of the standard solution, the bacterial concentration was considered equivalent to 1×10^8 CFU/mL (20).

Preparation of *Staphylococcus aureus*

Cryopreserved Staphylococcus aureus (Balai Laboratorium Kesehatan, Daerah Istimewa Yogyakarta) was inoculated into 0.9% NaCl solution (Merck, Germany). The turbidity of the bacterial suspension was then adjusted to 0.5 McFarland standard, corresponding to a concentration of 1×10^8 CFU/mL. Subsequently, serial dilution was performed by transferring 0.1 mL of the bacterial suspension into a sterile tube containing 9.9 mL of 0.9% NaCl solution (Merck, Germany) and mixing thoroughly. This procedure yielded a bacterial suspension with a final concentration of 1×10^6 CFU/mL (21).

Evaluation of Antibacterial Effect

The antibacterial activity of the gel formulations was evaluated using the agar well diffusion method. A 0.1 mL aliquot of the prepared bacterial suspension was inoculated onto Mueller–Hinton Agar (MHA) plates and evenly spread using a sterile spreader, then allowed to dry. Six wells were made in each plate using the tip of a sterile pipette. The test samples were carefully placed into the wells, followed by incubation at 37 °C for 24 h. The Petri dishes were kept on a flat surface to ensure uniform diffusion of the samples. Clindamycin (Dexa Medica, Indonesia) was used as a positive control, while the gel base served as a negative control. After incubation, the zones of inhibition formed around the wells were observed and measured in millimeters using a Vernier caliper.

Stability Test

The best gel formulation, selected based on organoleptic and physical evaluation results, was subjected to a stability test over three cycles. Each cycle consisted of storage under the following conditions: 2–8 °C for 24 h (refrigeration), 15–30 °C for 24 h (room temperature), and 40 °C with 75% relative humidity for 24 h in a climatic chamber (Memmert, Germany) (22, 23). At the end of each cycle, the gel was evaluated for its physical characteristics, including organoleptic properties, homogeneity, viscosity, spreading diameter, adhesion time, and pH.

Total Phenolic Content (TPC)

The best gel formulation was subjected to total phenolic content (TPC) analysis. The TPC was determined using the Folin–Ciocalteu reagent method as described by (24) with slight modifications. Briefly, 1 mg of red dragon fruit extract (RDFE) was dissolved in 1 mL of methanol–water (80:20 v/v). Then, 100 µL of the diluted extract was mixed with 7.9 mL of distilled water and vortexed for 10–20 s. Subsequently, 500 µL of Folin–Ciocalteu reagent was added, followed by 1.5 mL of 20% sodium carbonate solution, and the mixture was vortexed for 20–30 s. The reaction mixture was incubated at

room temperature for 2 h, after which the absorbance was measured at 765 nm using a UV–visible spectrophotometer (Shimadzu UV-1800, Japan). Gallic acid was used as a standard, and TPC values were expressed as milligrams of gallic acid equivalents per gram (mg GAE/g).

Data Analysis

Data from organoleptic evaluation, viscosity, homogeneity, spread diameter, adhesion time, and pH of the three formulations (prior to stability testing) were analyzed using SPSS version 26.0 at a 95% confidence level. Statistical analysis included the Shapiro–Wilk test for normality, Levene's test for homogeneity of variance, followed by one-way ANOVA and LSD post hoc tests. For the best formulation, physical characteristic data collected before and after the stability test were analyzed using the Shapiro–Wilk test for normality and a paired t-test to assess significant differences.

Results and Discussion

Red Dragon Fruit Extraction

In this study, the extraction was performed using a juicer, which directly separates the juice (filtrate) from the pomace, including the fiber and seeds. This method produces pure red dragon fruit juice without the need for any solvents. Ramli *et al*. (24) also used dragon fruit preparations in the form of juice to determine their effect on cardiovascular and hepatic changes in rats with metabolic syndrome. The weighed filtrate was then concentrated by heating it on a stove using a large porcelain cup placed over a water-filled infusion pot. The thickening process works by evaporating the water content from the juice, thereby reducing moisture to extend the shelf life and inhibit microbial growth. The stove serves as a heat source to accelerate the thickening, which takes approximately five h. Using an infusion pot filled with water ensures that the juice is heated indirectly, preventing direct contact with the flame and avoiding the formation of a crust on the surface.

The thickening process of red dragon fruit extract requires elevated temperatures (70–80 °C) to achieve a viscous consistency. According to Kemit *et al*. (25), heating above 80 °C can degrade flavonoid compounds, resulting in a decreased total flavonoid content. Conversely, heating below 70 °C prolongs the thickening process, which may also reduce flavonoid concentration and diminish the extract's therapeutic effects. Gao *et al*. (26) reported that the stability of dietary flavonoids varies under different thermal conditions, as flavonoid content is highly sensitive to temperature. Therefore, maintaining an optimal heating range is essential to preserve flavonoid integrity and maximize the biological activity of the extract.

The thickened RDFE was then calculated as the yield value and obtained a weight of 12.07%. Extract yield is the percent ratio between the weight of the thick extract (extract weight) and the weight of the sample preparation used (gross weight). Manik (27) obtained yield of red dragon fruit flesh extract ranges from 14.5%, using the maceration method with 96% ethanol as solvent. Ethanol is volatile, so it evaporates easily. In addition, this solvent has semi-polar characteristics so that it can attract flavonoid compounds in red dragon fruit, which are semi-polar as well. In this study, we did not use any solvent. Truong (28) added hydrolytic enzymes to red dragon fruit juice. This can increase the extraction yield and reduce the reducing sugar content in red dragon fruit juice.

Formula of Red Dragon Fruit Extract Gel

The potential of RDFE to be formulated into a gel is linked to its non-sticky and moisturizing properties. The extract can be uniformly distributed within the gel, which aids in the effective release of its active compounds from the gel base. The gel type used was hydrogel, as the semi-polar nature of the red dragon fruit extract supports the release of active ingredients from the formulation. The gel formulation includes RDFE as the active ingredient, Carbopol 940 as the gelling agent, and various excipients such as an alkalizing agent, humectant, preservative, solvent, and fragrance. Specifically, TEA was used as the alkalizing agent, glycerin as the humectant, methyl paraben as the preservative, distilled water as the solvent, and oleum rossae as the fragrance. In this study, different formulations of the red dragon fruit extract gel were prepared by varying the concentrations of TEA and Carbopol 940.

In gel formulation, one of the most important ingredients to use is a gelling agent. A good gelling agent is inert, non-toxic, and does not react adversely with other components (29). The gelling agent used in this research is Carbopol 940. Carbopol 940 belongs to the gelling agent class of synthetic polymers. Suryaningtyas (30) proved that Carbopol 940 is non-toxic and irritating and has no effect on the biological activity of the drug. The basis for selecting the gelling agent is that Carbopol 940 has a clear appearance, does not have a yellowish color, has good dispersion, has a cooling effect on the skin, and is easily washed off with water.

The alkalizing agent used in this study is TEA. TEA was chosen because it can neutralize the acidity of Carbopol 940 and can make the gel clear (31). The alkalizing agent in the gel formula is used when the gelling agent requires a neutralization reaction. Suppose Carbopol is dispersed in water and an alkalizing agent is added. In that case, a neutralization process occurs which results in a repulsive force on the COO-Carbopol 940 group which results in a more rigid structure and an increase in viscosity. The ionization process occurs when Carbopol 940 is dispersed in water and added with an alkalizing agent.

In this study, glycerin was used as the humectant. Humectants play a crucial role in gel formulations because they attract and retain water, helping to minimize water loss from the skin and maintain its hydration (32). Glycerin was selected due to its superior water-absorbing capacity, which is attributed to its numerous hydroxyl groups that enhance its ability to bind and hold moisture on the skin (33). Since gels contain a high percentage of water, preservatives are necessary to inhibit microbial growth that could compromise the effectiveness of the active ingredients and pose safety risks (34). Methyl paraben was employed as the preservative in this formulation

Organoleptic Characteristics

The F1, F2, and F3 gel formulations all exhibited the same clear purplish-red color, characteristic of red dragon fruit, as shown in **Figure 1** and **Table 3**. This red hue is attributed to betacyanin, a pigment found in red dragon fruit. Betacyanin belongs to the betalain pigment family, which includes two types: betacyanin, responsible for the purplish-red color, and betaxanthin, which imparts a yellow color (31-32). Betacyanin pigments are pH-sensitive, appearing red/violet in acidic conditions and changing to brown or yellow-green in alkaline solutions, while their stability is highest between a

Figure 1. Red dragon fruit extract gel. F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively

Table 3. The organoleptic characteristics of red dragon fruit extract gel.

Properties	F1	F2	F3
Color	Clear red-purple typical red dragon fruit	Clear red-purple typical red dragon fruit	Clear red-purple typical red dragon fruit
Odor	The distinctive aroma of oleum rossae	The distinctive aroma of oleum rossae	The distinctive aroma of oleum rossae
Consistency	Less thick	Thick enough	Thick

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively.

pH of approximately 4.0 and 6.0. Degradation accelerates significantly with increasing pH, especially above pH 8 (36-37). The uniform color across the three formulas is due to the identical 8% w/w concentration of the extract in each. The gel comprises a dispersed phase, consisting of polymers, and a dispersing phase, made up of water or other solvents. Gel systems may appear either clear or cloudy; in this case, all three formulations produced clear gels, indicating complete dispersion of the components. Regarding color, all three formulas meet the desired criteria, as the gel color accurately reflects that of the natural red dragon fruit.

All three formulas have a distinctive aroma of oleum rossae as an added fragrance. The stability of this aroma can be maintained by maintaining the moisture content in the extract and storing it in the refrigerator. If there is a foul smell, it indicates the presence of spoilage of a preparation. A bad smell can be caused if the extract is not stored in the refrigerator or still contains a lot of water. According to Mafe *et al.* (39) improper storage, such as not refrigerating the gel or allowing it to have a high water content, can accelerate the growth of microorganisms. This leads to chemical changes in the preparation, creating undesirable odors, along with changes in textures and appearance.

The three formulas have different consistency; the consistency of F3 > F2 > F1. This was caused by variations in the concentration of Carbopol 940 & TEA. The higher the concentration of Carbopol 940 & TEA, the higher the gel consistency. Safitri *et. al.* (40) and Sultan *et al.* (41) obtained the highest level of Carbopol 940, resulting in the highest viscosity of emulgel. On the other hand Nurman *et al.* (42) stated that TEA did not affect the viscosity of the gel preparations

Gel Homogeneity

The homogeneity test was designed to observe the homogeneity of the preparation marked by the absence of coarse grains on the slide. The homogeneity test aims to observe whether the base and extract are evenly dispersed. If the base and extract are not evenly dispersed, the therapeutic effect obtained is not the same every time you use it.

Based on the finding, all RDFE gel formulas were homogenous, and no coarse grains were observed on the slide. The gel is declared homogeneous if there are no coarse grains on the slide (12, 43). Good homogeneity in preparation tends to be easier and more comfortable to use and is evenly distributed when applied to the skin. Based on the data above, it can be concluded that the three RDFE gel formulas have met the requirements for good gel homogeneity (44)

Gel Viscosity

Gel viscosity is a crucial factor as it influences consumer preference. It refers to the gel's resistance to flow. The viscosity impacts the release of active ingredients from the gel, which in turn affects the gel's overall effectiveness. An ideal gel viscosity strikes a balance, being neither too thin nor too thick. If the gel is too fluid, it will adhere poorly to the skin, resulting in suboptimal release of the active compounds. Conversely, if the gel is excessively thick, the diffusion of active substances from the gel base becomes more difficult due to a reduced diffusion coefficient (29).

Based on **Figure 2A**, the order of viscosity at a speed of 25.4 rpm from the highest to the lowest was F3 > F2 > F1. This indicates that the higher the concentrations of Carbopol 940 and TEA, the higher the viscosity and the consistency of the gel. This is in line with Rahmatullah *et al.* (45), which states that gel viscosity is influenced by the gelling agent and alkalizing agent used. Septiawan (46) stated that Carbopol 940 has a positive effect on the viscosity response and TEA hurts the viscosity response, meaning that with the addition of Carbopol 940 concentration, the viscosity of the preparation will be greater, but with the addition of TEA resulted in a decrease in the viscosity of the preparation. The study also stated that the combination of Carbopol 940 and TEA can affect the viscosity of the preparation (46). The increase in viscosity is due to the repulsion between the groups, which has an impact on stretching the hydrogen bonds in the carboxyl group (47).

The gel preparation is expected to be easy to apply on the skin, which is indicated by a viscosity value that is not too low nor too high. Based on Danimayostu (15), a good gel viscosity is in the range of 2000-4000 cps. F1 does not meet the requirements of a good gel viscosity because it is less than 2000 cps. This happens because the concentration of Carbopol 940 is low, so the resulting viscosity is also low due

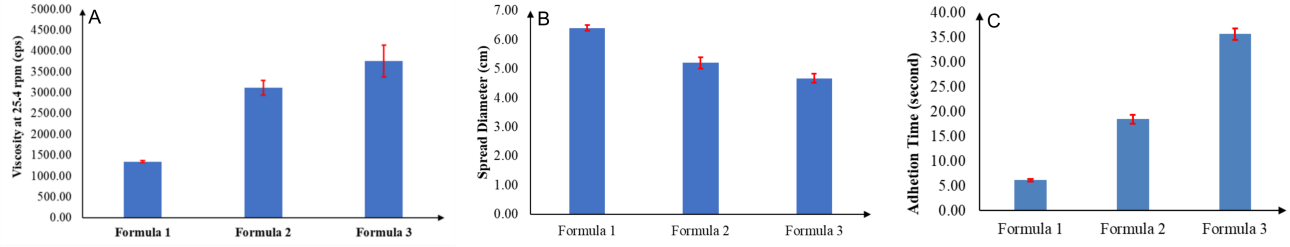

Figure 2. Physical properties of red dragon fruit (Hylocereus polyrhizus) extract gel: (A) viscosity, (B) spread diameter, and (C) adhesion time. The percentage ratios of Carbopol 940 to triethanolamine (TEA) in the formulations were 0.5:0.3 (Formula 1), 1.2:0.7 (Formula 2), and 2.0:1.2 (Formula 3).

to the smaller amount of polymer (48). The viscosities of the F2 and F3 have met the requirements of a good gel viscosity. Analysis of viscosity data using SPSS version 26.0 with a 95% confidence level. The LSD test showed significant differences between F1, F2, and F3. Variations in the concentration of Carbopol 940 and TEA significantly affect the gel viscosity.

Spread Diameter

The spread diameter test was carried out to determine the ability of the gel to spread when applied to the skin. This test is important to do because it relates to the distribution of active ingredients. If the gel can spread more widely on the surface of the skin, the distribution of the active ingredients will be better. Pratama and Zulkarnain (49) reported that the larger the diameter of the spread, the wider the gel contact with the skin surface so that the active substance could be distributed well. The results of the diameter test of the red dragon fruit extract gel distribution are shown in **Figure 2B**.

Based on **Figure 2B**, only the spread diameter values from formulas 1 and 2 have met the requirements for a good gel spreading diameter, which is in the range of 5-7 cm (50). In application, formulas 1 and 2 will be easier to apply on the skin without the need for great pressure. The order of the scatter diameter values from the largest to the smallest is F1 > F2 > F3. The greater the concentration of Carbopol 940, the smaller the diameter of the distribution. This is due to the high concentration of Carbopol 940, resulting in more gel network structures being formed and an impact on the decrease in the ability of the gel to spread. Rahayu *et al*. (51) reported that the higher the viscosity, the lower the diameter of the spread. The statement is proven in the results of this study that F1 has the lowest viscosity. Statistical analysis shows that variations in the concentration of Carbopol 940 and TEA significantly affect the spread diameter of the gel.

Adhesion Time

The adhesion time tested to determine the ability of gel to stick to the skin. This is related to the length of time the gel contacts the skin. The longer the gel contact time on the skin, the greater the absorption of the active substance so that the desired therapeutic effect can be achieved. The results of the sticking time of the red dragon fruit extract gel are shown in **Figure 2C**.

Based on **Figure 2C**, the order of attachment time values from the highest is F3 > F2 > F1. This indicates that the higher the concentration of Carbopol 940 and TEA, the higher the results of the adhesive time test. On the other hand, the lower the concentration of Carbopol 940 and TEA, the lower the results of the adhesive time test. Rahayu *et al*. (51) reported Carbopol 940 gave a positive response to the value of adhesion time with a coefficient value of 0.315. TEA gave a positive response to the value of sticking time, but the coefficient value was not as big as Carbopol 940, which was 0.244. Mixing between Carbopol 940 and TEA in the preparation showed a positive coefficient of 0.035. The value of the adhesive time test has a relationship with viscosity where the greater the viscosity of the gel, the longer the sticking time and the smaller the diameter of the spread. The greater the viscosity, the longer the ability of the preparation to adhere. All three formulas have met the requirements of a good gel adhesion time because it is more than 4 s (16). RDFE gel has a good adhesion time, so the absorbed active substance is greater.

Analysis of adhesion time data using SPSS version 26.0 with 95% confidence level. The results of the LSD test showed that there was a significant difference between F1, 2, and 3. Based on statistical analysis, it could be concluded that variations in the concentration of Carbopol 940 and TEA significantly affected the results of the RDFE gel sticking time.

pH

In this study, the pH test used a semi-solid preparation pH meter. The pH test is carried out to determine the degree of acidity of the preparations that have been made. In addition, this test is needed to ensure that the preparations that have been made are safe to use so that they do not cause irritation to the skin. Normal skin is in the pH range of 4.5-6.5 so the requirements for a good gel pH are the same as the normal pH of the skin.

Carbopol 940 contains 56-68% carboxylic acid and is an acidic polymer with a pH of 2.5-4 in a 0.2% w/v solution in water, while TEA as an alkalizing agent has alkaline characteristics with a pH of 10.5. Based on the orientation results, the greater the concentration of Carbopol 940, the more acidic the resulting pH will be, so more TEA is needed to form a pH that is close to normal. A neutralization process was carried out by adding an alkaline material to form a gel mass with a gelling agent in the form of Carbopol 940 to form a gel mass so that it reached a normal pH. Suppose the gel preparation is made with the gelling agent Carbopol 940

Table 4. Acidity of red dragon fruit extract gel.

Formula	pH
F1	5.45 ± 0.02
F2	5.44 ± 0.01
F3	5.43 ± 0.02

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively.

without the TEA alkalizing agent. In that case, the gel will not form and the resulting pH tends to be acidic so that it will irritate the skin and give a stinging sensation. While the gel is prepared with a TEA alkalizing agent without the gelling agent Carbopol 940, the gel will not be formed and the resulting pH tends to be alkaline so that it will make the skin scaly and itchy (52). The results of the pH test of the red dragon fruit extract gel are shown in **Table 4**.

Based on **Table 4**, the pH of the three formulas does not show any difference because the RDFE gel formula uses variations in the concentration of Carbopol 940 and TEA, with the same ratio of 1.7:1, resulting in a pH that is not different. The pH produced from the three formulas has met the requirements of a good gel pH, which is in the range of 4.5-6.5 (14, 17).

Red-fleshed dragon fruit has an original pH of approximately 5. Betacyanins are pH-sensitive pigments that are most stable and exhibit their characteristic red-violet color between pH 3 and 7, with optimal stability often found in the slightly acidic range of pH 5-6. At alkaline pH levels (above 8), betacyanins are unstable, rapidly degrade, and turn brown or light yellow, while extreme acidity below pH 3 can also cause degradation (53-55)

Antioxidant Activity

Antioxidant activity tests were carried out on F1, F2, F3, and ascorbic acid (control). This test was used to determine the potential of red dragon fruit gel in scavenging DPPH free radicals using the IC_{50} value. The higher of IC_{50} value, the lower of antioxidant activity (56). The results showed that F3 had the highest antioxidant activity (22.8 ± 0.47), followed by F2 and F1, respectively (**Table 5**). The antioxidant activity of F3 has a significant difference from F1 and F2 but is still below that of ascorbic acid as a positive control ($p < 0.05$). These results are lower than the antioxidant activity of red dragon aqueous extract. Nur *et al.* (57) reported that the antioxidant activity (DPPH IC_{50}) of aqueous extract of *H. polyrhizus* was 22.8 ± 0.47.

F3 with 2 % concentrations of Carbopol 940 and 1.2% concentration of TEA has the highest antioxidant activity against DPPH. The highest Carbopol 940 and TEA concentration the highest antioxidant activity of the gel, indicating that increased gelling agent and alkalizing agent concentration enhances antioxidant potential. Oliveira *et al.* (58) found that Carbopol 940 in hydrogels containing coumestrol-loaded nanoemulsions exhibited antioxidant potential. Asari (59) and Fiume (60) stated that TEA is an emulsifier and pH adjuster commonly used in skin gels and lotions to create stable formulations. Its role in an antioxidant gel is to help combine and stabilize the other ingredients, like plant extracts that provide the actual antioxidant activity, and to ensure the final product's stability and performance.

Table 5. Antioxidant activity of the red dragon fruit extract gel.

Formula	DPPH IC_{50} (ppm)
F1	36.76 ± 1.04^{d}
F2	29.65 ± 0.91^{c}
F3	22.8 ± 0.47^{b}
Ascorbic acid (control)	4.48 ± 0.37^{a}

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively. Values are mean ± standard deviation (n = 3). Values within treatments in a column with different superscript lowercase letters (a, b, c, d) differ significantly ($p < 0.05$).

Antibacterial Properties

The antibacterial properties of red dragon fruit extract gel were tested using *Staphylococcus aureus* bacteria. The test results showed that F1 produced the largest inhibition zone, followed by F2 and F3 (**Table 6**). There were significant differences in the inhibition zones between the treatment groups, including compared to the positive control group, Clindamycin. Clindamycin produced the largest inhibition zone (21.65 ± 0.387). Compared to the gel of ethanolic extract of red dragon fruit peel and pulp (61) the inhibition zones of the RDFE gel are larger.

The optimal concentration of Carbopol 940 is found by balancing its effect on the gel's physical properties with the desired release and penetration of the antibacterial agent. Aziza (62) found that a Carbopol 940 concentration of 0.5% was optimal for a specific gel formulation. The concentration of Carbopol 940 in a gel does not directly increase antibacterial activity, but it plays a crucial role in the gel's physical properties, which in turn affect the bioavailability and release of the antibacterial agent. Generally, higher Carbopol 940 concentrations lead to increased viscosity, which can improve the gel's adhesion, stability, and the release rate of the active substance, ultimately enhancing its antibacterial effect (9).

TEA is used to neutralize acidic components in a gel, such as carbomers, raising the overall pH. This is crucial for stabilizing the gel and creating the desired consistency. By optimizing the gel's physical properties, such as viscosity, TEA helps ensure the even distribution of antibacterial agents throughout the product, making it more consistently effective. Giovana (63) found that antibacterial activity is primarily determined by the concentration and type of the active antibacterial agent in the gel. TEA's role is to create a stable and effective delivery system for these agents.

The Most Optimal Formula

The best formula for RDFE gel was determined by selecting a formula that meets the criteria for each parameter, evaluates the gel's physical characteristics, and possesses great antioxidant activity and antibacterial properties. Evaluation of the physical characteristics of the gel was carried out by observing the organoleptic, homogeneity, viscosity, dispersion diameter, sticking time, and pH. The results of the evaluation of the physical Characteristics of the RDFE gel before the stability test are summarized in **Table 7**.

Based on the results of the evaluation of the physical characteristics of the three formulas in **Table 7**, F1 met the requirements for the physical characteristics of the gel in the form of organoleptic (color, odor, and consistency), pH, homogeneity, dispersion diameter, and adhesion time. Nevertheless, F1 did not meet the physical requirements in the form of viscosity because it is less than the normal range of gel viscosity, which is 2000-4000 cps (64). This can be caused by the concentration of Carbopol 940, which is too small so that the viscosity is not as high as F2 and F3. F3 fulfilled the requirements for the physical characteristics of the gel in the form of organoleptic (odor, color, and consistency), viscosity, homogeneity, adhesive time, and pH. F3 does not meet the physical requirements of the gel in the form of a spread diameter. This can be caused by the

Table 6. Antibacterial properties of the red dragon fruit extract gel.

Formula	Inhibition zone (mm)
F1	19.05 ± 0.420[c]
F2	17.57 ± 0.330[b]
F3	15.27 ± 0.250[a]
Clindamycin (control)	21.65 ± 0.387[d]

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively. Values are mean ± standard deviation (n = 3). Values within treatments in a column with different superscript lowercase letters (a, b, c, d) differ significantly ($p < 0.05$).

concentration of Carbopol 940, which is too large, so that the gel produced is too thick, and the viscosity is large and inversely proportional to the results of the spread diameter test.

Based on the antioxidant activities and antibacterial properties test, F2 has antioxidant activity and antibacterial properties that are between those of F1 and F3. F3 has the highest antioxidant activity, followed by F2 and F1. For antibacterial properties, F1 has the highest inhibition zone, followed by F2 and F3. Based on these results, it can be concluded that F2 has better potential for antioxidant activity and antibacterial properties compared to F3 and F1.

F2 fulfilled all the requirements for the physical characteristics of the gel in the form of organoleptic (color, aroma, and consistency), pH, homogeneity, spread diameter, adhesion time, and viscosity. F2 also has better antioxidant activity and antibacterial properties than F1 and F3. It can be concluded that the best formula for RDFE gel is F2, with variations in Carbopol 940 and TEA concentrations of 1.2% and 0.7%, respectively. The best formula, as determined, is followed by a stability test to assess the gel's stability in storage under specific temperature conditions.

Total Phenolic Content (TPC) of F2

Phenolic compounds are one of the important antioxidants in plants. They maintain a balance between oxidants and antioxidants in the body. In this research, we got the TPC of RDFE gel was 7,581 ± 0.141.This result was lower compared to the TPC of RDFE (65). Senturk *et al.* (62) found no correlation between the antioxidant activity and the amount of polyphenols in emulgel. It can be difficult to identify the exact components in the extracts that contribute to the antioxidant action because of their complex composition. This is further complicated by the possibility that the compounds in the extract may interact in ways that are synergistic, additive, or neutralizing.

Physical Stability

The best formula (F2) was tested for stability, which consisted of storage at a temperature of 2-8 ˚C in the refrigerator (24 h), then stored at 15-30 °C indoors (24 h), and stored at 40 °C in a climatic chamber with relative humidity of 75% (24 h). The stability test was carried out for 9 days (3 cycles), where each cycle took 72 h, so that in 3 cycles took 216 h. This stability test is categorized as an accelerated stability test. Normally the long-term stability test is carried out for 1 year. The results of the evaluation of the physical characteristics of the RDFE gel before and after the stability test are summarized in **Table 8**.

The organoleptic results (**Table 8**) indicated that the best formula after the stability test met the requirements in terms of color because it matched the distinctive color of the red dragon fruit. RDFE contains betalain pigments, providing colors ranging from yellow to violet to structures that in other plants are colored by anthocyanins. The stability of betalain derivatives can be affected by several factors, such as temperature and pH. The color of betalains is stable around pH 3.5–7.0, and is most stable at pH 5.5–5.7. Their color can change from blue to violet and yellow-brown with increasing pH. These changes can also be gradually altered by heat treatment (67). In this stability test, there are no color changes in the gel, indicating a promising pigment for skin application

Based on the results of the homogeneity test in **Table 8**, the best formula after the stability test, the absence of coarse grains on the glass, met the requirements of good gel homogeneity. Gel preparations are declared homogeneous if there are no coarse grains on the slide (12). Preparations that have good homogeneity tend to be easier and more comfortable to use and are evenly distributed when applied to the skin.

The viscosity test in **Table 8** showed that the viscosity of the RDFE gel decreased after the stability test. The decrease in viscosity can be caused by high temperatures, which can lead to polymer degradation. The degradation causes the cross-link bonds to break the gel structure. This condition causes the particles to be at a large distance so that the forces between the particles are reduced. The greater the distance between the particles, the lower the viscosity (68). The viscosity produced from the two samples has met the requirements in the range of 2,000-4,000 cps (15). The viscosity level is intended to minimize the water content in the gel preparation so that it is applied to the skin to reduce the growth of microorganisms. The Shapiro-Wilk normality test showed that the data were normally distributed on the best RDFE gel formula before ($p = 0.857$) and after the stability test ($p = 0.409$). Paired T-test results showed no significant difference between the viscosity of the best RDFE gel formula before and after the stability test ($p = 0.203$). The results of this statistical analysis indicate that the RDFE gel has a stable viscosity during the storage process.

The spread diameter test in **Table 8** indicated the best formula for the RDFE gel after the stability test decreased due to the influence of storage temperature. If there is a change in temperature during storage, there will be a change in viscosity, which can change the value of the diameter of the spread (69). The lower the viscosity of the gel, the larger the diameter of the spread. The scattering diameter of the two samples still met the requirements for a good gel spreading diameter, which was in the range of 5-7 cm (50).The Shapiro-Wilk normality test showed that the data were normally distributed on the best RDFE gel formula before ($p = 1.000$) and after the stability test ($p = 1.000$). Paired T-test value of the diameter of the spread gel showed no significant difference between the results of the diameter of the spread gel before and after the stability test ($p = 0.102$). The results of the statistical analysis can be concluded that the RDFE gel has a stable dispersion diameter in the storage process.

Based on the adhesion time test (**Table 8**), the best formula for the RDFE gel after the stability test decreased due to the influence of storage temperature. This is the same as the results of the spread diameter test, where temperature affects the viscosity of the gel. The lower the viscosity of the gel, the larger the diameter of the spread,

Table 7. Physical characteristics of the RDFE gel (before the stability test).

Physical characteristics	F1	F2	F3
Color	Clear purplish red typical red dragon fruit	Clear purplish red typical red dragon fruit	Clear purplish red typical red dragon fruit
Odor	The distinctive aroma of *oleum rossae*	The distinctive aroma of *oleum rossae*	The distinctive aroma of *oleum rossae*
Consistency	+	++	+++
pH	5.45 ± 0.02	5.44 ± 0.01	5.43 ± 0.02
Homogeneity	Homogeneous	Homogeneous	Homogeneous
Scatter diameter (cm)	6.40 ± 0.10	5.20 ± 0.20	4.67 ± 0.15
Adhesion time (second)	6.13 ± 0.25	18.45 ± 0.89	35.62 ± 1.11
Viscosity 25,4 rpm (cps)	1341.49 ±22.60	3112.47 ±177.90	3756.30 ±386.08

Note: F1, F2, and F3 represent gel formulations with Carbopol 940 and TEA percentage ratios of 0.5:0.3, 1.2:0.7, and 2.0:1.2, respectively. (+) = less think, (++) = thick enough, and (+++) = thick.

Table 8. Physical characteristics of the best RDFE gel formula 2 (F2) before and after the stability test.

Physical characteristics	Stability test results		Information
	Before	After	
Color	Clear purplish red typical red dragon fruit	Clear purplish red typical red dragon fruit	-
Odor	The distinctive aroma of *oleum rossae*	The distinctive aroma of *oleum rossae*	-
Consistency	Viscous	Viscous	-
Viscosity 25,4 rpm (cps)	3112.47 ± 178	2756.63 ± 170.25	Not significantly different
Homogeneity	Homogeneous	Homogeneous	-
Scatter diameter (cm)	5.2 ± 0.20	5.7 ± 0.10	Not significantly different
Adhesion time (second)	18.45 ± 0.89	16.51 ± 0.53	Not significantly different
pH	5.44 ± 0.01	5.42 ± 0.01	Not significantly different

but the faster the adhesion time. However, the results of the adhesive time test produced from the two samples met the requirements for a good gel adhesion time of > 4 s (16). The Shapiro-Wilk normality test showed that the data were normally distributed before (p = 0.246) and after (p= 0.979) the stability test. The paired T-test value of the RDFE gel attachment time showed no significant difference between the results of the RDFE gel attachment time before and after the stability test (p = 0.074). The results of statistical analysis can be concluded that the RDFE gel has a stable adhesion time in the storage process.

The pH test (**Table 8**) showed the best formula for RDFE gel after the stability test decreased due to the influence of temperature, light, and storage time. However, the pH produced from the two samples met the requirements, which was in the pH range of 4.5-6.5 (50). The Shapiro-Wilk normality test showed that the data were normally distributed on the best RDFE gel formula before (p = 1.000) and after (p = 1.000) stability test. Paired T-test values of RDFE gel pH showed no significant difference between the results of RDFE gel pH before and after the stability test (p = 0.184). The results of the statistical analysis can be concluded that the RDFE gel has a stable pH during the storage process.

The stability test is crucial for confirming the quality, safety, and effectiveness of an RDFE gel throughout its shelf life by assessing its physical characteristics under various storage conditions, especially extreme temperatures. Manufacturers must conduct these tests before commercial production to ensure key parameters like organoleptic properties (odor, color, consistency), homogeneity, viscosity, spread diameter, adhesive time, and pH do not change significantly over time. This process is a mandatory step for regulatory approval before the product can be marketed (70).

This study has several limitations, including its primary focus on the physical characteristics and stability of the red dragon fruit extract gel without assessing its biological efficacy, such as antioxidant or anti-aging effects, on skin models or through clinical trials. Additionally, only three specific ratios of Carbopol 940 and TEA were tested, potentially overlooking other optimal formulations. The stability testing was limited to three cycles under controlled temperature and humidity conditions, without evaluation of long-term shelf life or real-world storage scenarios.

Conclusion

Red dragon fruit extract can be successfully formulated into a gel using 1.2% Carbopol 940 and 0.7% TEA, resulting in a product with desirable physical characteristics, good homogeneity, stable pH, and favorable viscosity, spreadability, and adhesion. The optimized formulation (F2)

demonstrated the best combination of physical properties, antioxidant activity, and antibacterial effects. Stability testing confirmed that the gel maintains its quality under various storage conditions. These results indicate that red dragon fruit extract gel is a promising natural cosmeceutical product suitable for topical application.

Declarations

Author Informations

Novi Febrianti
Corresponding Author
Affiliation: Biology Education Study Program, Universitas Ahmad Dahlan, Yogyakarta, DIY, Indonesia.
Contribution: Conceptualization, Funding acquisition, Methodology, Supervision, Writing - Review & Editing.

Lina Widyastuti
Affiliation: Pharmacy Study Program, Universitas Ahmad Dahlan, Yogyakarta, DIY, Indonesia.
Contribution: Data Curation, Investigation, Supervision.

Septiana Saputri
Affiliation: Pharmacy Study Program, Universitas Ahmad Dahlan, Yogyakarta, DIY, Indonesia.
Contribution: Investigation, Writing - Original Draft.

Lalu Muhammad Irham
Affiliation: Pharmacy Study Program, Universitas Ahmad Dahlan, Yogyakarta, DIY, Indonesia.
Contribution: Writing - Review & Editing.

Acknowledgment

The authors wish to express their sincere appreciation to LPPM UAD for providing the research grant that supported this study.

Conflict of Interest

The authors declare no conflicting interest.

Data Availability

The unpublished data is available upon request to the corresponding author.

Ethics Statement

Not applicable.

Funding Information

This research was carried out with research grant funds from LPPM UAD with Grant No. PD-189/SP3/LPPM-UAD/VII/2022

References

1. Nishikito DF, Borges ACA, Laurindo LF, Otoboni AMMB, Direito R, Goulart R de A, et al. Anti-Inflammatory, Antioxidant, and Other Health Effects of Dragon Fruit and Potential Delivery Systems for Its Bioactive Compounds. Pharmaceutics. 2023 Jan 1;15(1).

2. Nurliyana R, Syed Zahir I, Mustapha Suleiman K, Aisyah MR, Kamarul Rahim K. Antioxidant study of pulps and peels of dragon fruits: A comparative study. Int Food Res J. 2010;17:367–75.

3. Esquivel P, Stintzing FC, Carle R. Pigment pattern and expression of colour in fruits from different Hylocereus sp. genotypes. Innov Food Sci Emerg Technol. 2007 Sep;8(3):451–7.

4. Taira J, Tsuchida E, Katoh MC, Uehara M, Ogi T. Antioxidant capacity of betacyanins as radical scavengers for peroxyl radical and nitric oxide. Food Chem. 2015;166:531–6.

5. Fatimi HA, Ramadhana IH, Awalinda, Purnama MF. Dragon Fruit Peels Waste as Cosmetic: An Overview. J Farm. 2025;7(2):210–9.

6. Suharyani I, Rindiyani R, Yulia, SR, Nurdianti L, Falya N. Application of Red Dragon Fruit Extract (Hylocereus polyrhizus) as an Antioxidant in Lip Cream Preparation. Indo J Pharm. 2023;5(1): 347-356

7. Smith J, Lee A. Formulation of Gel Cosmetics Using Natural Gelling Agents. J Cosmet Sci. 2020;71(4):245–56.

8. Patel S, Prajapati S. Gels as a Topical Drug Delivery System: A Review. Int J Pharm Sci Res. 2017;8(4):1418–27.

9. Apriani EF, Kornelia N, Amriani A. Optimizing Gel Formulations Using Carbopol 940 and Sodium Alginate Containing Andrographis paniculata Extract for Burn-Wound Healing. J Farm Dan Ilmu Kefarmasian Indones. 2023;10(3):300–11.

10. Tsabitah AF, Zulkarnain AK, Wahyuningsih MSH, Nugrahaningsih DAA. Optimasi Carbomer, Propilen Glikol, dan Trietanolamin Dalam Formulasi Sediaan Gel Ekstrak Etanol Daun Kembang Bulan (Tithonia diversifolia). Maj Farm. 2020;16(2):111.

11. Swastika A, Mufrod, Purwanto. Antioxidant Activity of Cream Dosage Form of Tomato Extract (Solanum lycopersicum L.). Tradit Med J. 2013;18(3):2013.

12. Ardana M, Aeyni V, Ibrahim A. Formulasi dan Optimasi Basis Gel HPMC (Hydroxy Propyl Methyl Cellulose) dengan Berbagai Variasi Konsentrasi. J Trop Pharm Chem. 2015;3(2):101–8.

13. Oetary S. Pengaruh Surfaktan Non Ionik yang Dicampur dalam Basis Salep Hidrofil (USP) terhadap Pelepasan Asam Salisilat secara In Vitro. Tesis. Universitas Gadjah Mada; 1987.

14. Kaur L., Garg R, Grupta G. Development and Evaluation of Topical Gel of Minoxidil from Different Polymer Bases in Application of alopecia. Int J Pharm Pharm Sci. 2010;2(3).

15. Danimayostu AA. Pengaruh Penggunaan Pati Kentang (Solanum tuberosum) Termodifikasi Asetilasi-Oksidasi Sebagai Gelling Agent Terhadap Stabilitas Gel Natrium Diklofenak. Pharm J Indones. 2017;3(1):25–32.

16. Ulaen S, Banne Y, Suatan R. Pembuatan Salep Anti Jerawat dari Ekstrak Rimpang Temulawak (Curcuma xanthorrhiza Roxb.). J Ilm Farm Poltekkes Manad. 2012;3(2):96587.

17. Mappa T, Edy HJ, Kojong N. Formulasi Gel Ekstrak Daun Sasaladahan (Peperomia Pellucida (L.) H.B.K) Dan Uji Efektivitasnya Terhadap Luka Bakar Pada Kelinci (Oryctolagus Cuniculus). J Ilm Farm. 2013;2(2):2302–493.

18. Khasanah I, Ulfah M. Uji Aktivitas Antioksidan Ekstrak Etanolik Kulit Buah Jeruk Nipis (Citrus aurantifolia) Dengan Metode DPPH (1,1-difenil-2-pikrilhidrazil).

19. Nurliyana R, Syed Zahir I, Mustapha Suleiman K, Aisyah MR, Kamarul Rahim K. Antioxidant study of pulps and peels of dragon fruits: A comparative study. Int Food Res J. 2010;17:367–75.

20. Kavoosi G, Rahmatollahi A, Mohammad Mahdi Dadfar S, Mohammadi Purfard A. Effects of essential oil on the water binding capacity, physico-mechanical properties, antioxidant and antibacterial activity of gelatin films. LWT. 2014;57(2):556–61.

21. Oonmetta-aree J, Suzuki T, Gasaluck P, Eumkeb G. Antimicrobial properties and action of galangal (Alpinia galanga Linn.) on Staphylococcus aureus. Food Sci Technol. 2006;39(10):1214–20.

22. Siti Salwa Abd Gani, Mahiran Basri, Mohd Basyaruddin Abdul Rahman, Anuar Kassim, Raja Noor Zaliha Raja Abd Rahman, Abu Bakar Salleh Zi. Characterization and Effect on Skin Hydration of Engkabang-Based Emulsions. Biochem Mol Biol Regul Pap. 2010;74(6):1188–93.

23. Dwiastuti R, Ardiyati ES. Formulasi sediaan gel nanopartikel lipid ekstrak daun binahong (Anredera cordifolia (Ten.) Steenis). 2020;3(2):40–6.

24. Stankovic M, Niciforovic N, Topuzofic M, Solujic S. Total Phenolic

Content, Flavonoid Concentration, and Antioxidant Activity of the Whole Plant and Plant Parts Extracts from Teucrium montanum L. Var Montanum, F. supinum (L.) Reichenb. Biotechnol Biotechnol Equip. 2011;25(1):2222–7.

25. Kemit N, Permana, Mayun PKD. Stabilitas senyawa flavonoid ekstrak daun alpukat (Persea americana Mill.) terhadap perlakuan pH dan suhu. Media Ilm Teknol Pangan. 2019;6(1).

26. Gao Y, Xia W, Shao P, Wu W, Chen H, Fang X, et al. Impact of thermal processing on dietary flavonoids. Curr Opin Food Sci. 2022;48(Figure 2):100915.

27. Manik IG. Formulasi dan Uji Efektivitas Ekstrak Buah Naga Merah (Hylocereus Costaricensis (F.A.C. Weber)) Sebagai Anti-Aging pada Kulit dalam Sediaan Krim. 1st ed. Medan: Universitas Sumatera Utara; 2017.

28. Phuong NM, Tuan Q. Application of Hydrolytic Enzymes for Improvement of Red Dragon Fruit Juice Processing. Dep Food Technol Int Univ - Viet Nam Natl Univ HCM city Quater 6, Ho Chi Minh city, Viet Nam. 2016;4(1):1–4.

29. Nurdianti L. Formulasi dan Evaluasi Gel Ibuprofen dengan Menggunakan Viscolam Sebagai Gelling Agent. J Kesehat Bakti Tunas Husada. 2015;14(1):47–51.

30. Suryaningtyas R. Pengaruh Variasi Jumlah Carbopol sebagai Gelling agent terhadap Sifat Fisik dan Stabilitas Fisik Sediaan Sabun Cuci Tangan Ekstrak Etanol Daun Beluntas. Skripsi. Universitas Sanata Dharma. 2014.

31. Saryanti D, Setiawan I, Safitri RA. Optimasi Formula Sediaan Krim M/A Dari Ekstrak Kulit Pisang Kepok (Musa acuminata L.). J Ris Kefarmasian Indones. 2019;1(3):225–37.

32. Harwood A, Nassereddin A, Krishnamurthy K. Moisturizers. 2025.

33. Kataoka Y, Kitadai N, Hisatomi O, Nakashima S. Nature of Hydrogen Bonding of Water Molecules in Aqueous Solutions of Glycerol by Attenuated Total Reflection (ATR) Infrared Spectroscopy. Appl Spectrosc. 2011 Apr 1;65(4):436–41.

34. Halla N, Fernandes IP, Heleno SA, Costa P, Boucherit-Otmani Z, Boucherit K, et al. Cosmetics preservation: A review on present strategies. Vol. 23, Molecules. MDPI AG; 2018.

35. Nishikito DF, Borges ACA, Laurindo LF, Otoboni AMMB, Direito R, Goulart R de A, et al. Anti-Inflammatory, Antioxidant, and Other Health Effects of Dragon Fruit and Potential Delivery Systems for Its Bioactive Compounds. Pharmaceutics. 2023;15(1).

36. Huang Y, Brennan MA, Kasapis S, Richardson SJ, Brennan CS. Maturation process, nutritional profile, bioactivities and utilisation in food products of red pitaya fruits: A review. Foods. 2021 Nov 1;10(11).

37. Khan MI, Liu J. Plant betalains: Recent applications in food freshness monitoring films. Food Packag Shelf Life [Internet]. 2022 Dec 1 [cited 2025 Sep 29];34:100921.

38. Mikołajczyk-Bator K, Czapski J. Effect of pH Changes on Antioxidant Capacity and the Content of Betalain Pigments during the Heating of a Solution of Red Beet Betalains. Polish J Food Nutr Sci. 2017;67(2):123–8.

39. Mafe AN, Edo GI, Makia RS, Joshua OA, Akpoghelie PO, Gaaz TS, et al. A review on food spoilage mechanisms, food borne diseases and commercial aspects of food preservation and processing. Food Chem Adv. 2024 Dec 1 [cited 2025 Oct 1];5:100852.

40. Safitri FI, Nawangsari D, Febrina D. Overview: Application of Carbopol 940 in Gel. 2021;34(Ahms 2020):80–4.

41. Sultan ARW, Ropiqa M, Apridamayanti P, Anastasia DS. Formulation and Antioxidant Activity Emulgel Senggani Leaf (Melastoma malabathricum L.) Water Fractions with Variations of Gelling Agent Using DPPH Method. Med Sains J Ilm Kefarmasian. 2024;9(3):737–48.

42. Nurman S, Yulia R, Irmayanti, Noor E, Sunarti TC. The optimization of gel preparations using the active compounds of arabica coffee ground nanoparticles. Sci Pharm. 2019;87(4).

43. Anggraeni W, Al-Hakim NA, Maharani NI. Evaluation of Sunflower Seed Oil Emulgel with Carbopol 940: Physical Properties and Moisturizing Effectiveness. Indones J Pharm Educ. 2025;5(1):12–26.

44. Rahayu YC, Setiawatie EM, Rahayu RP, Kusumawardani B, Ulfa NM. Formulation and in Vivo Evaluation of Nanoemulgel-Containing Cocoa Pod Husk (Theobroma Cacao L.) Extract As Topical Oral Preparation. Int J Appl Pharm. 2024;16(5):204–10.

45. St.Rahmatullaha, Slamet, Wulan Agustin Ningrumb NKD. Formulasi dan Evaluasi Sediaan Gel Hand Sanitizer Sebagai Antiseptik Tangan dengan Variasi Basis Karbopol 940 dan Tea. CHMK Pharm Sci J. 2020;3(3):189–94.

46. Septiawan D. Perbandingan Variasi Jumlah Trietanolamin Terhadap Stabilitas Sifat Fisik dan Sifat Kimia Gel Antiseptik Ekstrak Bunga Rosella (Hibiscus sabdariffa L.). 2012.

47. Husnani H, Firdaus AM. Optimasi Parameter Fisik Viskositas, Daya Sebar Dan Daya Lekat Pada Basis Natrium Cmc Dan Carbopol 940 Pada Gel Madu Dengan Metode Simplex Lattice Design. J Ilmu Farm dan Farm Klin. 2017;14:11–8.

48. Mursal, ILP, Kusumawati AH, Puspasari DH. Pengaruh Variasi Konsentrasi Gelling Agent Carbopol 940 Terhadap Sifat Fisik Sediaan Gel Hand Sanitizer Minyak Atsiri Daun Kemangi (Ocimum Sanctum L.). Pharma Xplore J Ilm Farm. 2019;4(1):268–77

49. Pratama WA, Zulkarnain AK. Uji SPF In Vitro Dan Sifat Fisik Beberapa Produk Tabir Surya Yang Beredar Di Pasaran. Maj Farm. 2015;11(1):275–83.

50. Garg, A, Aggarwal, D, Garg, S, Sigla AK. Spreading of Semisolid Formulation: An update. In: Pharmaceutical Technology. 2002. p. 84–102.

51. Rahayu T, Fudholi A, Fitria A. Optimasi Formulasi Gel Ekstrak Daun Tembakau (Nicotiana Tabacum) dengan Variasi Kadar Karbopol940 dan Tea Menggunakan Metode Simplex Lattice Design (Sld). J Ilm Farm. 2016;12(1):22–34.

52. Simon P. Formulasi dan Uji Penetrasi Mikroemulsi Natrium Diklofenak dengan Metode Sel Difusi Franz dan Metode Tape Stripping. 2012;1–112.

53. Lukitasari DM, Indrawati R, Chandra, RD, Heriyanto, Shioi Y, Botosudarmo TH. pH-dependent stability of major betalains in the encapsulated beetroot extracts (Beta vulgaris L.). J Food Sci. 2024;89(5):2761–73.

54. Tang, C.S, Tang C., Norziah M.H NM. Stability of Betacyanin Pigments from Red Purple Pitaya Fruit (Hylocereus polyrhizus): Influence of pH, Temperature, Metal Ions and Ascorbic Acid. Indones J Chem. 2010;7(3):327–31.

55. Siow LF, Wong YM. Effect of juice concentration on storage stability, betacyanin degradation kinetics, and sensory acceptance of red-fleshed dragon fruit (Hylocereus polyrhizus) juice. Int J Food Prop. 2017 Mar 4;20(3):623–32.

56. Paniwnyk L, Alarcon-Rojo A, Rodriguez-Figueroa JC, Toma M. The Use of Ultrasound as an Enhancement Aid to Food Extraction. Ingredients Extraction by Physicochemical Methods in Food. 2017. 399–440 p.

57. Nur A, Uddin MR, Sultana N, Uddin MJ, Amin MZ. In vitro anti-oxidant, anti-inflammatory, anti-bacterial, and cytotoxic effects of extracted colorants from two species of dragon fruit (Hylocereus spp.). Food Chem Adv. 2023;2(April):100318.

58. Oliveira LK, Argenta DF, Balestrin LA, Medeiros-Neves B, Fachel FNS, Mautone H, et al. Effect of gelling agents on properties of coumestrol-loaded nanoemulsions – Formulation, skin retention/permeation, antioxidant and skin photoprotective activities. J Drug Deliv Sci Technol [Internet]. 2024 Sep 1 [cited 2025 Oct 10];98:105834.

59. Asari YD, Nur' Aini L, Ikmalanas S, Paramita V. Effectiveness of Triethanolamine as Emulsifier in Chamomile Lotion Stability. J Vocat Stud Appl Res. 2024;6(1):17–20.

60. Ueno H, Yamakura S, Arastoo RS, Oshima T, Kokubo K. Systematic evaluation and mechanistic investigation of antioxidant activity of fullerenols using β -Carotene bleaching assay. J Nanomater. 2014;2014(Figure 1).

61. Rahayu YC, Sabir A, Setyorini D. Antibacterial activity of red dragon fruit extract (Hylocereuspolyrhizus) on Streptococcusmutans. Int J Appl Pharm. 2019;11(Special Issue 4):60–3.

62. Aziza FN, Syazwina Z, Suwardjo WP. Optimization of HPMC and Carbopol 940 as Gelling Agents on The Physical Properties and Stability in Anti-Acne Gel of Binahong Leaves (Anredera cordifolia (Ten.) Steenis Extract. Indones J Pharm. 2025;36(3):479–88.

63. Giovana C, Daniela VCM, Thalita FFM, Hérida SR, Marlus C. Antibacterial activity of gels with pomegranate, apricot and green tea glycolic extracts. J Appl Pharm Sci. 2012;2(12):13–6.

64. Pamuladiman, AR Widyastuti L. Formulation and the Antibacterial Activity of Mulberry leaves extract Gel (Morus alba L.) against Staphyococcus aureus. J Ilmu Kefarmasian Indones. 2020;19(1):39–48.

65. Febrianti N, Mubarika S, Pratiwi P, Hertiani T. Antioxidant Potency of Red Dragon Fruit Flesh and Peel Prepared by Different Methods. Curr Nutr Food Sci. 2019;16:1–8.

66. Şentürk TB, Barak TH, Çağlar EŞ, Saldamlı E, Özdemir Nath E, Özdemir ZÖ. A Bioactive Emulgel Formulation of Equisetum telmateia Ehrh. Methanol Extract: Integrating Antioxidant Activity, Skin Enzyme Inhibition, and Permeation Kinetics. Gels. 2025;11(8):1–26.

67. Gandía-Herrero F, Escribano J, García-Carmona F. Biological Activities of Plant Pigments Betalains. Crit Rev Food Sci Nutr. 2016;56(6):937–45.

68. Anggraeni Y, Hendradi E, Purwanti T. Karakteristik Sediaan Dan Pelepasan Natrium Diklofenak Dalam Sistem Niosom Dengan Basis Gel Carbomer 940. PharmaScientia. 2012;1(1):1–15.

69. Lumentut, N., Edy, H.J., Rumondor E. Formulasi dan Uji Stabilitas Fisik Sediaan Krim Ekstrak Etanol Kulit Buah Pisang Goroho (Musa acuminafe L.) Konsentrasi 12.5% sebagai Tabir Surya. J MIPA. 2020;9(2):42–6.

70. Mühlich L. ASEAN Guidelines on Stability Study and Shalef-Life of Health Supplements. Advancing Regional Monetary Cooperation. 2014. 154–195 p.

Additional Information

How to Cite

Novi Febrianti, Lina Widyastuti, Septiana Saputri, Lalu Muhammad Irham. Formulation and Stability Evaluation of Red Dragon Fruit (*Hylocereus polyrhizus*) Extract Gel. *Sciences of Pharmacy*. 2025;4(4):239-250

Publisher's Note

Open Access