

# THE STUDY OF GEL BODY LOTION CONTAINING INDRAMAYU MANGO (*MANGIFERA INDICA* L.) PEEL EXTRACT

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**Abstract.** The skin of Indramayu mango contains secondary metabolite compounds such as phenols and flavonoids that function to inhibit the enzyme Hyaluronidase (HYALase), which is an enzyme that breaks down hyaluronic acid. Hyaluronic acid plays a role in maintaining moisture in the skin. The extract of Indramayu mango skin is formulated into a gel preparation due to its good spreading properties on the skin, clear appearance, stability during storage, and resistance to flowing on the skin surface, allowing the active substances from the extract to remain in contact with the skin for a longer period. This study aims to test the stability of the gel preparation of Indramayu mango skin extract (*Mangifera indica* L.). The gel preparations were made in 4 formulas with different concentrations of Indramayu mango skin extract: F0 (without extract), F1 (0,15 g Indramayu mango skin extract/ 100 g), F2 (0.27 g Indramayu mango skin extract/ 100 g), and F3 (0.5 g Indramayu mango skin extract/ 100 g). The physical stability test of the gel preparation was carried out at temperatures of 28°C and 40°C for 28 days. Data analysis was performed using SPSS software, employing one-way ANOVA for normally distributed data and the Kruskal–Wallis test for data that did not meet normality assumptions. The stability test results indicated that F3 had the best stability during the 28-day storage, as shown by the results of the homogeneity test, pH, viscosity, spreadability, and adhesion, which did not experience significant changes during storage.

**Keywords:** *Mangifera indica*, gel, carbopol, stability

## Introduction

Mango (*Mangifera indica* L.) is a plant that is widely found and has various benefits because it contains secondary metabolites in the roots, leaves, fruit, skin, flowers, and seeds. Indramayu mango is a type of mango that has several advantages, namely, it can grow well in lowlands, which make it more resistant to physical damage, have a sweet taste when ripe, and when young it does not taste sour, but tends to be crispy and fresh. Indonesian people usually use mangoes only the fruit, while the skin of the mango is generally thrown away because many people are still not aware of its benefits (Yanty et al., 2022). This has caused an increase in waste in the environment, the increase reaching 12-15%, which includes organic waste (Rahmawati and Rini, 2021). Mango peel, especially from unripe fruit, contains higher levels of bioactive compounds such as phenols and flavonoids compared to the fruit itself. According to Kim et al. (2010), young mango peel extract contains total phenolic and flavonoid contents of 92.6 mg GAE/g and 22.2 mg/g, respectively. In comparison, ripe mango peel contains 70.1 mg GAE/g phenolics and 21.2 mg/g flavonoids. These compounds exhibit antioxidant and enzyme-inhibiting properties that support their potential as active ingredients in topical preparations.

Research by García-Villegas et al. (2023) showed that mango peel extract with a total phenolic content of 42.20 mg GAE/gram using 80% ethanol solvent can inhibit the hyaluronidase (HYALase) enzyme with an IC50 value of 27 mg/L. HYALase is an enzyme that breaks down hyaluronic acid, which plays a role in maintaining skin

moisture. Gel is a semi-solid preparation that can moisturize the skin and is well absorbed when applied (Sidiq and Apriliyanti, 2018). Gel is chosen because of its good spreading properties, clear appearance, stability during storage, and ability to stay longer on the skin surface (Andini and Putri, 2021; Sidiq and Apriliyanti, 2018). Carbopol 940 was chosen as the gelling agent based on research by Santoso (2021), who found that 1.5% carbopol 940 produced the most stable gel compared to Na-CMC and HPMC. Carbopol 940 is also non-toxic and does not irritate the skin, making it suitable for repeated use (Safitri et al., 2021; Rowe et al., 2006). Based on the above description, this study aims to formulate gel preparations containing varying concentrations of Indramayu mango peel extract and to evaluate their physical stability through organoleptic observations, homogeneity, pH, viscosity, spreadability, and adhesion tests.

## Materials and Methods

The equipment used included standard laboratory glassware (Pyrex®), viscometer (DV-I Prime®), pH meter (Starter 5000®), freeze dryer (EVELA®), stability oven, homogenizer (IKA RW20®), rotary evaporator (IKA HB10®) and other supporting tools used in the laboratory. The materials included young Indramayu mango peel, carbopol 940, triethanolamine, phenoxyethanol, 1,3-propanediol, and analytical-grade solvents. This research was conducted from February to April 2025 at the Pharmacy Laboratory of the Faculty of Mathematics and Natural Sciences, Pakuan University, Bogor. The Indramayu mango peels used were young Indramayu mangoes obtained from an Indramayu mango orchard located in Temiyangsari Village, Kroya District, Indramayu Regency, West Java. The results of the plant determination indicate that the plants used in this study are Indramayu mangoes of the *Mangifera indica* L. tribe Anacardiaceae.

### *Making simplicia*

The method of making simplicia used is a modification of the method García-Villegas et al. (2023). The mango peels used were from young mangoes, approximately three months old when picked. Afterward, the mangoes were thoroughly washed under running water. The peels were manually separated from the flesh, rinsed with water to remove any residue, and then drained. After cleaning and draining, the mango peels were weighed and oven-dried at 60°C.0C until dry, that is, when the mango skin is crispy when broken. Once dry, grind it and sift it through a 30-mesh sieve.

### *Extract preparation*

The extraction method used is a modification of the method by García-Villegas et al. (2023) as well as Ifmaily et al., (2023). The extraction process is carried out using the maceration method, where 250 grams of simplicia powder is soaked in 500 mL of 80% ethanol in a glass jar, covered with a black cloth, and left to stand for 24 hours while occasionally stirred. After that, it is filtered, collecting the macerate while the residue is re-macerated with 500 mL of 80% ethanol (1:2) up to 7 times (García-Villegas et al, 2023). The total macerate obtained is then concentrated using a rotary evaporator to evaporate the solvent. The resulting extract is then dried using freeze-drying to produce dry extract, which is stored in a tightly closed glass container with silica gel.

### ***Characterization of simplicia and extracts***

Characterization of simplicia and extracts of mango peel was conducted including tests for moisture content, total ash content, acid-insoluble ash content, following the methods in the Indonesian Pharmacopoeia edition 6 (Rahma, 2021): Weighing about 2 grams of the sample, which is then carefully transferred to a container that has been previously tared, allows us to determine the moisture content of the simplicia and the extract of mango peels. Preheat the oven to 105°C, then watch for five hours. Every hour, weigh the dry material until two subsequent weigh-ins differ by less than 0.25% (Rahma, 2021). 2 grams of the simplicia and mango peel extract are carefully weighed before being added to a silica crucible that has been calcined at 1050°C and tared in order to determine the ash content of the mixture. After gradually heating it until no charcoal is left, allow it to cool and weigh it once more. If the carbon residue cannot be eliminated using this approach, add hot water, agitate, and filter through ash-free filter paper. The filter paper and any leftover sediment should be calcined in the same crucible. Once the filtrate has evaporated, pour it into the crucible and calcine it at 800±25° until the weight remains constant. The weight of the test sample is used to determine the total ash content, which is then expressed as % b/b (Rahma, 2021). Following the determination of the Ash Content (AC), the ash is heated for five minutes in 25 milliliters of diluted hydrochloric acid in order to determine the Acid-Insoluble Ash Content of Mango Fruit Peel Extract. After collecting the insoluble materials from the acid, they are filtered through ash-free filter paper, cleaned with hot water, and then calcined in a crucible at 800 ± 25°C until they reach a consistent weight. Based on the weight of the material under analysis, the percentage w/w indicates the amount of acid-insoluble ash (Rahma, 2021).

Flavonoids, alkaloids, tannins, saponins, terpenoids, and steroids were among the phytochemical tests used to identify the secondary metabolites present in the simplicia and extracts of mango fruit skin. Weighing 0.5 grams of the sample combined with 5 milliliters of 96% ethanol, then taking 2 milliliters and adding 0.1 grams of magnesium powder and 10 drops of concentrated HCl from the tube's side, and gently shaking, was how the flavonoid test was carried out. The presence of flavonoids is indicated by the production of a red or orange tint. After weighing 0.5 grams of the sample, 1 milliliter of 2N HCl and 9 milliliters of distilled water were added for the alkaloid test. After 15 minutes of heating over a water bath, the mixture was allowed to cool before being filtered. Dropping the filtered solution onto a watch glass was followed by the addition of alkaloid reagents (Dragendorff, Mayer, and Bouchardat). The production of a reddish-brown precipitate with Bouchardat reagent, a red to orange precipitation with Dragendorff reagent, and a yellowish-white precipitate with Mayer reagent are all signs of positive results. In order to perform the tannin test, 0.2 g of the sample is dissolved in 2 mL of distilled water in a test tube. Next, a 1% FeCl solution is added in two or three drops. Catechin tannins are indicated by the creation of a blue-green hue, whereas gallic tannins are indicated by the formation of a blue-black color. After dissolving the extract in a small amount of aquadest and heating it in a water bath, 1% gelatin solution (1:1) is added to a different test tube. A white precipitate's development indicates a successful outcome. To perform the Saponin test, weigh 0.5 grams of the sample, put it in a test tube, and then add 10 milliliters of hot water. After cooling, it is violently shaken for ten seconds. The production of stable foam for at least one minute indicates a positive result containing saponins. In order to perform the final test for terpenoids and steroids, the

methanol sample was dissolved in chloroform, filtered, and the filtrate was examined for sterols and triterpenoids. The testing was then performed using the Liebermann Burchard method, where a few drops of acetic anhydride were added to the chloroform solution, shaken, and 1 mL of concentrated sulfuric acid was carefully added from the side of the test tube. Sterols are indicated by a reddish-brown hue, while triterpenoids are indicated by a red ring (Heliawati, 2018).

### ***Making indramayu mango peel extract gel***

Carbopol 940 is first developed in hot water at a temperature of 80°C, left for 24 hours, then homogenized with homogenizer, then add a little triethanolamine until the pH matches the skin between 4.5-6.5 (mass 1). Phenoxyethanol is added to mass 1 and then stirred using homogenizer. Mix mango peel extract and 1,3 propanediol using silent crusher at a speed of 20,000 rpm for  $\pm$  5 minutes (mass 2) then mix mass 2 into mass 1, stir with homogenizer until homogeneous (mass 3). Add distilled water until the weight reaches 100 g and ensure all ingredients are homogeneous homogenizer (García-Villegas et al., 2023) (*Table 1*).

***Table 1. Modified Indramayu mango peel extract gel formulation.***

Composition	Formula (% b/b)				Function in formulation
	F0	F1	F2	F3	
Mango Peel Extract	-	0,15	0,27	0,5	Active Substance
Karbopol 940	1,5	1,5	1,5	1,5	Gelling agent
TEA	0,25	0,25	0,25	0,25	Alkylating agent
Phenoxyethanol	1	1	1	1	Preservative
1,3 propanediol	9	9	9	9	Enhancer
Aquadest until	100	100	100	100	Solvent

### ***Test the stability of mango fruit peel extract gel***

Stability testing was conducted with accelerated stability at a temperature of 40°C $\pm$ 2°C and room temperature of 28°C $\pm$ 2°C for 28 days, with the physical quality evaluated on days 0, 7, 14, 21, and 28. The physical evaluation conducted includes organoleptic tests, pH tests, viscosity, spreading ability, and adhesion (Ratnapuri et al., 2019): (1) organoleptic examination: The color, odor, and consistency of the preparation were observed directly as an organoleptic evaluation process (Ifmaily et al., 2023); (2) homogeneity test: Testing was performed using a glass slide. After applying the gel sample evenly and thinly to the glass surface, the gel samples were examined for coarse particles or color variations (Ifmaily et al., 2023); (3) pH test: A pH meter is an instrument used to measure pH levels. One gram of gel is weighed and diluted with 10 mL of distilled water. The calibrated pH meter is then dipped into the gel sample for testing, and the resulting pH value is recorded (Ifmaily et al., 2023). pH testing is also performed to ensure that the gel sample meets the criteria of SNI 06-2588-1985, which states that a healthy pH range for skin is between 4.5-6.5; (4) viscosity test: A Brookfield viscometer was used to measure viscosity. A sample weighing 100 grams was placed into the viscometer beaker glass and the spindle is dipped. The rotor is activated and tested at 10, 20, 50, and 100 rpm with different spindle numbers 1, 2, 3, 4, 5, 6, and 7, the selection of rpm speed and spindle number is based on the results of the torque percentage closest to 100% (Ratnapuri et al., 2019). According to SNI 16-4399-1996, the standard viscosity value for a good gel preparation is 6000-50,000 cP; (5)

spread power test: On a transparent glass covered with graphic paper at the bottom, 0.5 grams of gel formulation was placed in the middle, covered with another transparent glass, and a load of 50 grams was applied every minute until the weight reached 250 grams. The diameter of the gel spread zone was measured vertically, horizontally, diagonally to the right and left. A good topical preparation has a spread ability of 5-7 cm (Ratnapuri et al., 2019); (6) adhesion test: On the surface of a glass slide, 0.5 grams of gel is applied to a predetermined surface area. Afterward, a 1 kg load is applied to the slide for 5 minutes. The slide is then mounted on the test apparatus, the load is released, and the time until the two slides separate is recorded. Adequate adhesion is required for at least 4 seconds (Ratnapuri et al., 2019).

### **Statistical analysis**

Data from the stability tests (pH, viscosity, spreadability, and adhesion) were analyzed using IBM SPSS® Statistics 27. Normality was assessed using the Shapiro–Wilk test. If data were normally distributed ( $p > 0.05$ ), analysis continued with one-way ANOVA. A Levene’s test was used to check homogeneity; if the data were homogeneous, a Bonferroni post hoc test was applied; otherwise, the Games–Howell test was used. If the data were not normally distributed ( $p < 0.05$ ), the Kruskal–Wallis test was used, followed by the Mann–Whitney U test if significant differences were found ( $p < 0.05$ ). All analyses were performed at a 95% confidence level ( $\alpha = 0.05$ ) (Shintyawati et al., 2024; Fitriana, 2018).

### **Results and Discussion**

The results of the preparation of simplicia from Indramayu mango peel showed a yield of 22.57%, as can be seen in *Table 2 (Figure 1)*. The moisture content obtained was 6.79%, which meets the criteria for good mango peel moisture content, which is  $\leq 10\%$  (Andini and Putri, 2021), the moisture content of simplicia must meet the criteria to avoid mold growth that can damage the quality of simplicia (Rosmayati et al., 2023). The ash content test conducted aims to determine the content of inorganic compounds and minerals present in simplicia; the ash content of mango peel simplicia was 5.72%, which meets the criteria for good mango peel ash content, which is  $\leq 8\%$  (Andini and Putri, 2021). The dry extract of Indramayu mango peel was obtained through the freeze drying method, which uses a temperature of  $-46.1^\circ\text{C}$ . This method was chosen because it reduces the risk of degradation of compounds present in the mango peel extract, can effectively preserve the quality and content of the dried compounds, and maintains the stability of the extract, resulting in a high-quality extract during storage and preserving the color of the extract well (Pratiwi et al., 2023), this makes the extract formulated into gel preparations produce a good color. The extract of Indramayu mango peel has a weak characteristic aromatic smell with a yellowish-green color as shown in *(Figure 1)*. The moisture content of the dry extract of Indramayu mango fruit peel is 3.83%, and this result meets the criteria for the moisture content of dry extracts  $< 5\%$  in Irsyad (2013), thus helping to avoid fungal and microbial growth and maintaining the quality of the dry extract during storage. The ash content of the extract was obtained at 2.47%, this test was conducted to provide an overview of the mineral content from the initial process up to the formation of the extract; the ash content result also meets the criteria for good ash content, which is in the range of 1%-5% in Yanty et al. (2022). The insoluble ash content was found to be 0.59%, this result meets the criteria for a good insoluble ash

content <2% according to *Materia Medika Indonesia* (MMI) in Mustaruddin (2022). The degree of purity in the extraction process is determined by testing the ash that is insoluble in acid (Andini and Putri, 2021).

**Table 2.** *Phytochemical test.*

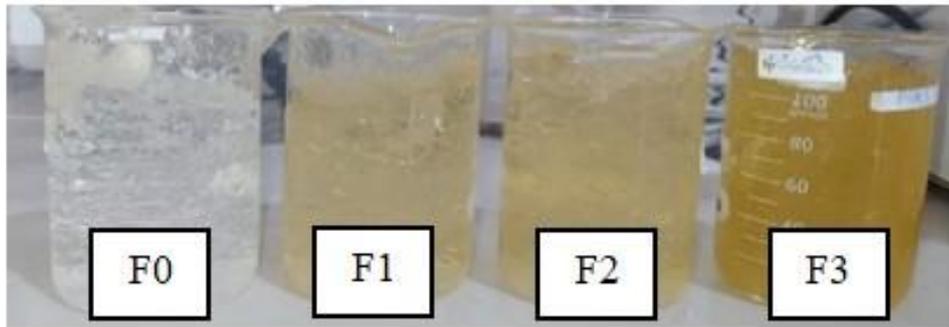
Test	Simple ingredients	Description	Simple ingredients	Description
Alkaloid				
Dragendorff	+	Red sediment	+	Red sediment
Mayer	+	Yellowish sediment	+	Yellowish sediment
Bouchardat		Brown sediment		Brown sediment
Tanin				
FeCl <sub>3</sub>	+	Blackish blue	+	Blackish blue
Gelatin	+	White sediment	+	White sediment
Flavonoid	+	Orange	+	Red
Saponin	+	Foam	+	Foam
Terpenoid & Steroid	-	Reddish orange	-	Reddish brown
	+		+	

*Note: (-)=Negative means there are no secondary metabolite compounds; (+)=Positive presence of secondary metabolite compounds.*



**Figure 1.** *Simplicia of mango fruit skin (left side) and extract the skin of the mango fruit (right side).*

The simplicia and mango peel extract had positive flavonoids, alkaloids, tannins, saponins, and steroids, according to the results of phytochemical screening; however, the terpenoid test yielded negative results. The first stability test result, the organoleptic evaluation, showed that during 28 days of observation, there were no significant changes in odor and texture among the four gel formulations. However, differences in color intensity were observed between formulas, which correlated with the concentration of mango peel extract used. As shown in *Figure 2*, the increase in extract concentration resulted in a more intense color of the gel. At a storage temperature of 40°C, the color intensity of the gel formulations increased progressively from day 7 to day 28. The observed increase in color intensity is likely attributed to the higher concentration of phenolic compounds, which are susceptible to oxidation and degradation at elevated temperatures. This thermal-induced breakdown may have contributed to the darker appearance of the gel over time (García-Villegas et al., 2023). The results of the second stability test, which is the homogeneity test, indicate that there is no change in homogeneity during storage at both 28°C and 40°C. This shows that the gel formulation remains stable during storage. The formulation must remain homogeneous as it relates to the uniformity of the active ingredient content in each use (Ambari et al., 2021).

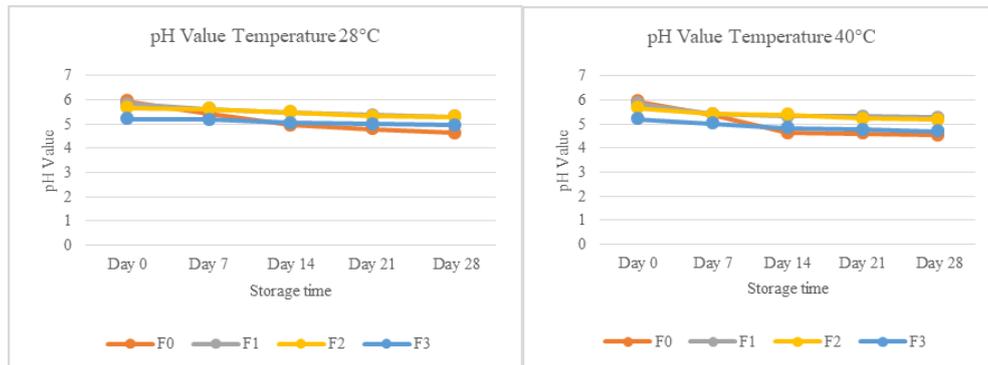


**Figure 2.** Mango peel extract gel.

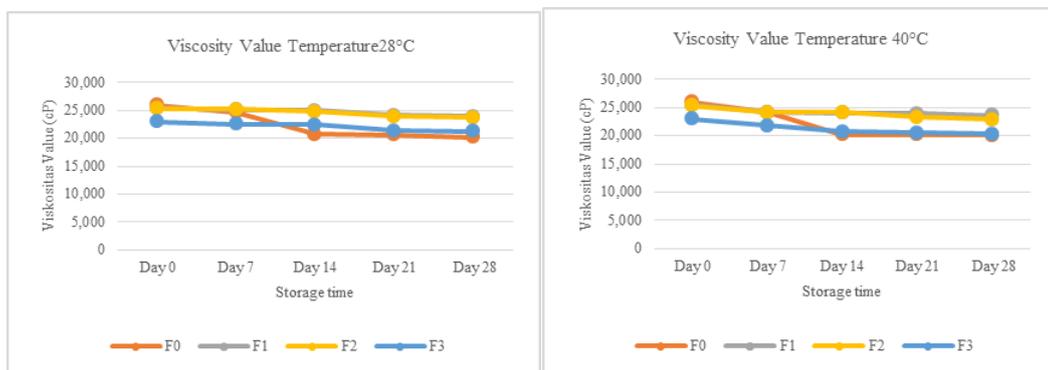
*Note: F0=Does not contain Indramayu mango peel extract; F1=Contains 0.15% Indramayu mango peel extract; F2=Contains 0.27% Indramayu mango peel extract; F3=Contains 0.5% Indramayu mango peel extract.*

The pH test results indicate that the gel preparation's pH becomes increasingly acidic as the extract concentration increases. This is because the gel preparation's pH dropped as a result of the higher concentration of mango peel extract, which has an acidic pH of 3.688. The results of the pH testing over 28 days also showed a decrease in pH as storage time increased. Statistically, significant decreases in pH ( $p < 0.05$ ) occurred in F0 ( $p = 0.001$ ), F1 ( $p = 0.008$ ), and F2 ( $p = 0.019$ ), indicating instability of the formulation during storage. The Bonferroni test showed that a significant decrease occurred on day 14 for F0 and F1, as well as on day 21 for F2. Meanwhile, F3 showed a nonsignificant decrease in pH ( $p = 0.185$ ), indicating better pH stability. However, the decrease in pH still remained within the good gel formulation pH range according to SNI 06-2588-1985, which is 4.5–6.5. This is also in line with the findings of García-Villegas et al. (2023), which show that when the quantity of mango peel extract increases, the pH of the preparation decreases. This is explained by the bioactive compounds' acidic qualities, which are caused by the presence of phenolic compounds in the extract, particularly phenolic acids and organic acids. During storage, triethanolamine (TEA) may become less effective at neutralizing the acidic properties of the carbopol base (Slamet et al., 2020), leading to hydrolysis of the TEA cation as a weak base, generating  $H^+$  ions that caused the pH to become more acidic (Pertwi et al., 2020). Additionally, an increase in storage temperature could also lead to a decrease in pH due to the release of acidic groups from the carbopol (Slamet et al., 2020) (Figure 3). The results of the viscosity testing show that the more acidic the pH of the gel preparation, the lower the viscosity. This is due to the use of Carbopol 940 as a gelling agent, which works at pH 3-11 and produces a thick viscosity at pH 5-11 (Rowe et al., 2006). During storage, the viscosity of the formulation also decreases, which may be due to the influence of storage time and temperature increase. An increase in temperature can break polymer bonds, making the preparation more liquid, and its molecules move, thus weakening the intermolecular interaction forces. Consequently, the viscosity of the preparation will decrease with an increase in temperature (Slamet et al., 2020). The viscosity of the gel preparations decreased over the 28-day storage period, with values ranging from 25,955 cP to 20,060 cP at 40°C and 25,955 cP to 21,300 cP at 28°C, indicating a general decline in viscosity across all formulas as storage time and temperature increased. However, the viscosity decrease that occurs in all formulas over 28 days still meets the viscosity range requirements for a good gel preparation according to Indonesian National Standard SNI 16-4399-1996, which is 6000-50,000 cP. Statistical tests showed

that the decrease in viscosity over 28 days was not significant ( $p > 0.05$ ), with the following sig values:  $F_0 = 0.113$ ;  $F_1 = 0.061$ ;  $F_2 = 0.050$ ;  $F_3 = 0.121$ , meaning that there was no effect of storage time on viscosity (*Figure 4*).



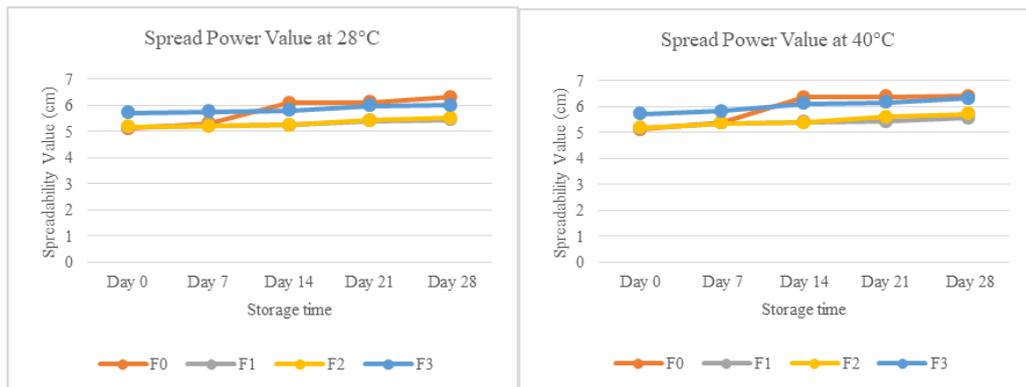
**Figure 3.** Results of pH stability test at temperature 28°C (left side) and results of pH stability test at temperature 40°C (right side).



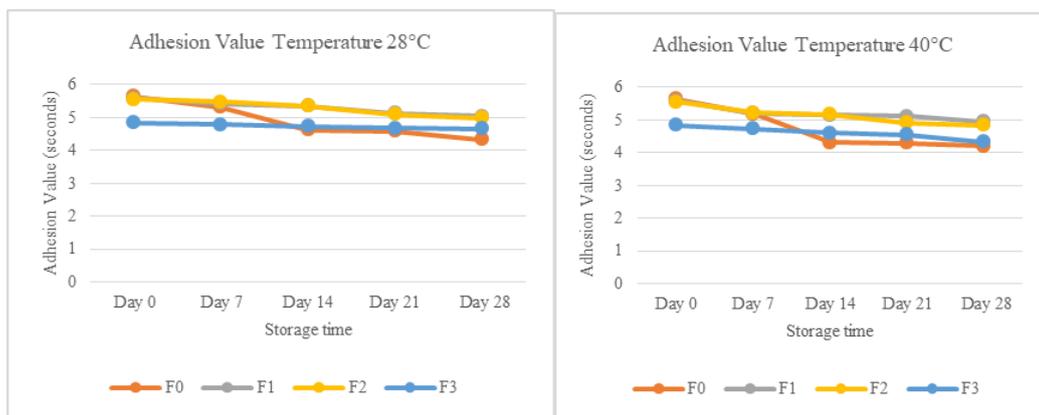
**Figure 4.** Results of the viscosity stability test at 28°C (left side) and results of the viscosity stability test at 40°C (right side).

The results of the spreadability stability test indicate that viscosity is inversely proportional to spreadability, meaning that the higher the viscosity, the lower the spreadability of the preparation. During the 28-day storage, spreadability increased as can be seen in *Figure 5* due to a decrease in viscosity, but it remained within the appropriate range (5–7 cm) (Ratnapuri et al., 2019). Statistically, significant increases in spreadability occurred in  $F_0$ ,  $F_1$ , and  $F_2$  ( $p < 0.05$ ; sig respectively  $< 0.001$ ; 0.028; 0.034), indicating instability of spreadability during storage. Based on the Games-Howell test, significant increases occurred on day 28 for  $F_0$  and  $F_1$ , and on day 21 for  $F_2$ . Meanwhile,  $F_3$  did not show significant changes ( $p = 0.131$ ), indicating that the spreadability of  $F_3$  remained stable during storage. As seen in *Figure 6*, the adhesion stability test results revealed a decline over the course of the 28-day storage period. This decline was brought on by an increase in spreadability and a decrease in the preparation's viscosity during storage, which decreased the gel preparation's ability to adhere. Stronger bonds between the gel and the skin enable greater absorption of the active ingredient, which is why a good gel has a high adhesion capability (Susianti et al., 2021). Statistically, a significant decrease in adhesion ( $p < 0.05$ ) occurred in  $F_0$ ,  $F_1$ , and  $F_2$  (sig  $< 0.001$ ; 0.014; 0.016), with significant changes occurring on day 28 based on the Games-Howell test, indicating that the adhesion is unstable during storage.

Meanwhile, F3 did not show significant changes ( $p=0.190$ ), therefore its adhesion is declared stable.



**Figure 5.** Results of the spreadability stability test at 28°C (left side) and results of the spreadability stability test at 40°C (right side).



**Figure 6.** Results of the adhesion stability test at a Temperature of 28°C (left side) and results of the adhesion stability test at a Temperature of 40°C (right side).

## Conclusion

This study investigates the formulation and stability of gel preparations containing Indramayu mango (*Mangifera indica* L.) peel extract, focusing on its potential as an active ingredient for skin care products. The findings emphasize both the therapeutic potential of mango peel and the stability of gel formulations, highlighting the challenges of maintaining formulation efficacy during storage under varying environmental conditions. Indramayu mango peel, particularly from young fruits, contains potent bioactive compounds, such as phenols and flavonoids that inhibit the hyaluronidase (HYALase) enzyme, a key player in the breakdown of hyaluronic acid. Hyaluronic acid is essential for maintaining skin hydration, and its preservation is vital for healthy skin aging and moisture retention. This biological property positions the mango peel extract as a promising natural ingredient for skin care, addressing the growing consumer demand for bio-based, effective, and sustainable cosmetic products. Through the formulation of gel preparations using Carbopol 940 as a gelling agent, this study successfully demonstrated that mango peel extract could be incorporated into a stable and effective gel system. The results indicate that the gel formulations exhibited good stability, with F3 (0.5 g extract/100 g) showing the best overall stability across multiple

physical parameters such as pH, viscosity, spreadability, and adhesion. These characteristics are critical in ensuring the product's functionality, aesthetic appeal, and long-term usability. The high concentration of active compounds in F3 appears to provide an optimal balance between therapeutic effect and physical stability, retaining its efficacy during the 28-day storage period. However, the study also highlighted the challenges associated with the storage stability of these gels.

Notably, the decrease in pH and viscosity over time, especially at elevated temperatures, pointed to potential instability, which is often due to the degradation of bioactive compounds or the interactions between the gelling agent and the extract. These findings emphasize the need for careful formulation adjustments to maintain the stability of the product over time, particularly for products intended for long-term use. While the viscosity of all formulations decreased during storage, the F3 gel formulation exhibited the least significant changes, suggesting it is the most resilient to temperature-induced degradation. Moreover, the increase in spreadability with decreasing viscosity is an expected outcome in gel formulations, but it also signifies a loss of the gel's consistency, potentially compromising its usability. The decline in adhesion observed across the formulations further underscores the delicate balance required in maintaining the product's integrity over time. In conclusion, while the study demonstrated the potential of Indramayu mango peel extract as a valuable ingredient in gel formulations, it also underscores the importance of conducting stability tests under various conditions to ensure the efficacy and safety of such cosmetic products. Further research is needed to refine these formulations, exploring ways to optimize their stability and maximize the therapeutic benefits of mango peel extract. Future studies should also focus on the scalability of the formulation, ensuring it is feasible for large-scale production while maintaining its beneficial properties. This research contributes to the growing body of knowledge on the use of natural, sustainable ingredients in cosmetic formulations and paves the way for more environmentally conscious skincare products.

### **Acknowledgement**

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### **Conflict of interest**

The authors attest that none of the parties involved in this research study have any conflicts of interest.

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