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Formulation and Physicochemical Evaluation of Spray Gel Containing *Cordyline fruticosa* L. Leaf Extract for Topical Delivery

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A B S T R A C T

Spray gel is a gel system applied through a spray pump, producing small or large liquid droplets. *Cordyline fruticosa* (L.) A. Cheval, commonly known as Andong Merah, is a plant with various medicinal properties, including wound healing activity attributed to its flavonoid content. This research aimed to formulate and evaluate the physicochemical properties of a spray gel containing *Cordyline fruticosa* leaf extract for topical delivery, focusing on the effects of different concentrations of Carbopol 940 as a gelling agent and sorbitol as a humectant. *Cordyline fruticosa* leaf extract was obtained by maceration using 96% ethanol. Three spray gel formulations were prepared, varying the concentrations of Carbopol 940 (0.4 g, 0.6 g, and 0.8 g) and sorbitol (5 ml, 7.5 ml, and 10 ml). The prepared spray gels were then subjected to physicochemical evaluation, including organoleptic tests (color, odor, and consistency), homogeneity tests, pH measurements, viscosity measurements, spray pattern analysis, and adhesion tests. All spray gel formulations exhibited acceptable physicochemical properties. The formulations were homogeneous, with a pH within the acceptable range for topical applications. The viscosity and adhesion properties varied with the concentrations of Carbopol 940 and sorbitol. The spray pattern analysis revealed a circular spread pattern, with the pressure required for spraying influenced by the viscosity of the formulation. The spray gel formulations containing *Cordyline fruticosa* leaf extract demonstrated good physicochemical qualities, indicating their potential suitability for topical delivery. Further studies are recommended to optimize the formulation for enhanced stability and therapeutic efficacy.

1. Introduction

Wound healing is a complex and dynamic physiological process that involves a series of coordinated events aimed at restoring the integrity of injured tissues. The process is characterized by four overlapping phases: hemostasis, inflammation, proliferation, and remodeling. These phases involve intricate interactions between various cells, growth factors, and extracellular matrix components. Traditional medicine has utilized a variety of natural products for centuries to promote wound healing. Plants, in particular, are rich sources of bioactive compounds that have been shown to possess wound-healing properties. These compounds exert their therapeutic effects through various mechanisms, including promoting cell proliferation, angiogenesis, collagen synthesis, and reducing inflammation. *Cordyline fruticosa* (L.) A. Cheval, commonly known as Andong Merah, is a plant with a long history of use in traditional medicine for treating various ailments, including wounds, burns, and skin infections. The plant is rich in bioactive compounds, including flavonoids, saponins, tannins, and steroids. These compounds contribute to the plant's diverse pharmacological activities, including wound healing, anti-inflammatory, and antioxidant effects. Flavonoids, in particular, are known for their ability to scavenge free radicals, inhibit hydrolytic and oxidative

enzymes, and exert anti-inflammatory effects. These properties make flavonoids promising candidates for wound healing applications, as they can protect tissues from oxidative damage, reduce inflammation, and promote tissue regeneration.[1-4]

Topical drug delivery offers several advantages over other routes of administration, such as localized action, reduced systemic side effects, and improved patient compliance. Topical formulations can deliver drugs directly to the site of action, minimizing systemic exposure and reducing the risk of adverse effects. Additionally, topical formulations are often easier to apply and can be self-administered, improving patient adherence to treatment regimens. However, conventional topical formulations, such as ointments and creams, may have limitations, including greasy texture, difficulty in application, and potential for contamination. These limitations can affect patient acceptance and compliance, highlighting the need for alternative topical delivery systems.[5,6]

Spray gel, a novel topical delivery system, offers a solution to the challenges associated with conventional topical formulations. It combines the benefits of gel and spray formulations, providing a convenient and hygienic method of application. The spray mechanism allows for even distribution of the formulation without direct contact, minimizing the risk of contamination and trauma to the affected area. Additionally, the gel matrix provides sustained release of the active ingredient, enhancing its therapeutic effect. Spray gels are formulated using a combination of gelling agents, humectants, and other excipients to achieve the desired viscosity, spreadability, and adhesion properties. The gelling agent provides the structural framework for the gel, while the humectant helps to retain moisture and prevent the formulation from drying out.[7,8]

Carbopol 940, a widely used gelling agent in pharmaceuticals and cosmetics, is known for its high stability, microbial resistance, and excellent thickening properties. It is a synthetic polymer that forms a clear gel upon neutralization with a base, such as triethanolamine (TEA). Carbopol 940 gels are known for their smooth texture, non-tackiness, and ease of spreadability, making them suitable for topical applications. Sorbitol, a humectant, is added to spray gel formulations to prevent moisture loss and improve the stability of the formulation. It is a sugar alcohol that is commonly used in pharmaceuticals and cosmetics due to its humectant, plasticizing, and sweetening properties. Sorbitol is known to be compatible with a wide range of excipients and is well-tolerated by the skin.[9,10] This study aimed to formulate and evaluate the physicochemical properties of a spray gel containing *Cordyline fruticosa* leaf extract for topical delivery.

2. Methods

Cordyline fruticosa leaves were collected from Ngebel, Ponorogo, East Java, Indonesia. The selection of leaves was based on their maturity, ensuring they were neither too young nor too old, and their freshness. This selection criterion is crucial as the phytochemical content and, consequently, the therapeutic potential of plants can vary significantly depending on their age and physiological state. Younger leaves may contain lower levels of bioactive compounds, while older leaves may have undergone degradation processes, reducing their efficacy. Following collection, the *Cordyline fruticosa* leaves were subjected to a crucial step: authentication. This process, also known as taxonomic identification, involves confirming the identity of the plant material by comparing its morphological and anatomical features with established taxonomic references. In this study, the authentication was performed at the Faculty of Biology, Universitas Gadjah Mada (UGM), a reputable institution with expertise in plant taxonomy. This step is essential to ensure that the correct plant species are used in the study, preventing potential errors arising from misidentification and ensuring the reliability and reproducibility of the research findings.

The authenticated *Cordyline fruticosa* leaves underwent a series of preparatory steps before extraction. These steps are crucial for ensuring the efficiency of the extraction process and the quality of

the final extract; Washing: The leaves were thoroughly washed under running water to remove any adhering dust, soil, or other contaminants. This step is important for minimizing the risk of microbial contamination and ensuring the purity of the extract; Drying: The washed leaves were then dried in a controlled environment to remove moisture content. Drying is essential for preventing the growth of mold and bacteria during storage and for improving the stability and shelf life of the plant material. The drying process was carried out in a shaded area to prevent the degradation of heat-sensitive bioactive compounds. This method, known as shade drying, is preferred for medicinal plants as it helps to preserve their therapeutic properties; Grinding: The dried leaves were ground into a fine powder using a suitable grinder. Grinding increases the surface area of the plant material, facilitating better penetration of the solvent during extraction and enhancing the extraction yield. The particle size of the powder is also important, as finer particles tend to yield more extract due to their larger surface area.

The extraction of bioactive compounds from the prepared *Cordyline fruticosa* leaf powder was performed using the maceration method. This method involves soaking the plant material in a solvent for an extended period, allowing the solvent to penetrate the plant cells and dissolve the desired compounds. Maceration is a simple and widely used extraction technique, particularly suitable for thermolabile compounds that may degrade at higher temperatures; Solvent Selection: 96% ethanol was chosen as the solvent for maceration. Ethanol is a commonly used solvent in plant extractions due to its ability to dissolve a wide range of polar and nonpolar compounds. The high concentration of ethanol (96%) was selected to maximize the extraction of flavonoids, the primary bioactive compounds of interest in this study. Flavonoids are relatively polar compounds and are more soluble in higher concentrations of ethanol; Maceration Process: The dried leaf powder was placed in a clean, dry container, and 96% ethanol was added at a specific ratio of plant material to solvent. The container was sealed and stored in a cool, dark place for five days. During this period, the mixture was shaken intermittently to ensure proper contact between the plant material and the solvent, facilitating efficient extraction; Filtration: After five days, the mixture was filtered through a cloth filter, typically made of cotton or muslin, to remove the marc (the solid residue of the plant material). This initial filtration removes the bulk of the solid particles, preparing the mixture for the next filtration step; Fine Filtration: The filtrate obtained from the cloth filtration was then subjected to a second filtration using filter paper. This step removes any remaining fine particles, resulting in a clear liquid extract; Extract Concentration: The final step in the extraction process involved concentrating the liquid extract using a rotary evaporator. This equipment operates under reduced pressure, allowing the solvent to evaporate at a lower temperature, preventing the degradation of heat-sensitive compounds. The concentrated extract was then stored at 4°C until further use. This low-temperature storage is crucial for maintaining the stability and efficacy of the extract.

In addition to the *Cordyline fruticosa* leaf extract, various chemicals were used in the formulation of the spray gels. These chemicals, also known as excipients, play crucial roles in determining the physicochemical properties and stability of the final product. Carbopol 940, a synthetic polymer, served as the gelling agent in the spray gel formulations. It is widely used in pharmaceuticals and cosmetics due to its excellent thickening and suspending properties. Carbopol 940 is known for its ability to form clear, non-sticky gels that are easy to spread and provide a pleasant sensory experience. Sorbitol, a sugar alcohol, was used as a humectant in the spray gel formulations. Humectants are substances that attract and retain moisture, preventing the formulation from drying out and maintaining its consistency. Sorbitol is a commonly used humectant in topical formulations due to its compatibility with other ingredients and its moisturizing properties. Triethanolamine (TEA), an organic compound, was used to neutralize the

Carbopol 940, facilitating the formation of a gel. Carbopol 940, in its acidic form, requires neutralization to activate its gelling properties. TEA, being a base, raises the pH of the Carbopol 940 dispersion, triggering the formation of a gel network. Methylparaben, an antimicrobial preservative, was added to the spray gel formulations to prevent microbial growth and ensure their safety and stability. Preservatives are essential in topical formulations to protect them from contamination by bacteria, fungi, and other microorganisms that can proliferate in moist environments. Distilled water, purified by boiling and condensation, was used as the solvent in the spray gel formulations. Distilled water is preferred in pharmaceutical preparations as it is free from impurities that may affect the stability and efficacy of the product. All chemicals used in this study were of analytical grade, ensuring their purity and suitability for pharmaceutical applications.

The formulation of spray gels involves a series of steps aimed at combining the active ingredient (*Cordyline fruticosa* leaf extract) with the excipients in a specific ratio to achieve the desired physicochemical properties. The formulation process requires careful consideration of the properties of each ingredient and their interactions to ensure a stable and effective product. The first step in the formulation process involved dispersing Carbopol 940 in distilled water. Carbopol 940, being a powder, needs to be properly dispersed in water to prevent clumping and ensure uniform gel formation. The dispersion was allowed to stand for a certain period to allow the Carbopol 940 particles to fully hydrate and swell, forming a viscous solution. Once the Carbopol 940 was fully dispersed, TEA was added to neutralize the acidic Carbopol 940 and activate its gelling properties. The addition of TEA raises the pH of the dispersion, triggering the formation of a gel network. The amount of TEA required for neutralization was carefully calculated to achieve the desired gel consistency. In a separate container, the *Cordyline fruticosa* leaf extract was dissolved in a portion of sorbitol. This step ensures that the extract is evenly distributed throughout the final formulation. Methylparaben, the preservative, was dissolved in the remaining portion of sorbitol. This separate dissolution ensures that the preservative is evenly distributed throughout the final formulation, preventing microbial growth and ensuring its stability. The Carbopol 940 gel base, the extract solution, and the methylparaben solution were then combined and mixed thoroughly until a homogeneous mixture was obtained. Homogeneity is crucial for ensuring that the active ingredient and excipients are evenly distributed throughout the formulation, providing consistent dosage and therapeutic effect. Distilled water was added to the mixture to adjust the final volume to the desired amount. This step ensures that the final formulation has the correct concentration of ingredients. The final spray gel formulation was then packaged in suitable containers, typically spray bottles, for ease of application. The containers were properly sealed to prevent contamination and maintain the stability of the formulation.

The physicochemical properties of the formulated spray gels were evaluated using various techniques to assess their quality and suitability for topical application. These evaluations provide valuable information about the characteristics of the formulations, including their appearance, texture, stability, and ability to deliver the active ingredient effectively. Organoleptic tests involve evaluating the sensory properties of the formulations, including color, odor, and consistency. These properties are important for patient acceptance and compliance, as they influence the perceived quality and appeal of the product. The color of the spray gel formulations was assessed visually, while the odor was evaluated by smelling the formulations. The consistency of the formulations was assessed by their texture and spreadability. Homogeneity tests were conducted to ensure that the spray gel formulations were uniform in composition, with no separation or clumping of ingredients. A small amount of each formulation was spread on a glass plate and visually inspected for any signs of non-uniformity or grittiness. This test is crucial for ensuring that the active ingredient and

excipients are evenly distributed throughout the formulation, providing consistent dosage and therapeutic effect. The pH of the spray gel formulations was measured using a calibrated pH meter. The pH of topical formulations is critical as it can affect the stability and efficacy of the product, as well as the skin's tolerance to the formulation. The skin's natural pH is slightly acidic, and formulations with a pH outside this range may cause irritation or disrupt the skin's barrier function. The viscosity of the spray gel formulations was determined using a Brookfield viscometer. Viscosity is a measure of a fluid's resistance to flow and is an important property of topical formulations as it affects their spreadability, adhesion, and drug release characteristics. The viscosity of the spray gel formulations was measured using an appropriate spindle, and the measurements were performed at room temperature. The spray pattern of each formulation was evaluated by spraying it onto a pre-weighed plastic sheet from different distances. The spray pattern is an important characteristic of spray gel formulations as it affects the coverage and uniformity of application. The diameter of the spray pattern was measured, and the pattern was visually assessed for uniformity. Adhesion tests were performed to assess the ability of the spray gel formulations to adhere to the skin. Adhesion is an important property of topical formulations as it affects the contact time between the formulation and the skin, influencing drug absorption and therapeutic efficacy. The adhesion of the spray gel formulations was evaluated by applying a small amount of each formulation to the skin of the forearm and measuring the time it took for the formulation to detach when the arm was held vertically.

Statistical analysis was performed on the data obtained from the physicochemical evaluations to determine the significance of the results and to identify any trends or patterns. The data were analyzed using one-way analysis of variance (ANOVA) to compare the means of different groups. Tukey's post hoc test was used to identify specific differences between pairs of groups. A p-value of less than 0.05 was considered statistically significant, indicating that the observed differences were unlikely to have occurred by chance.

3. Results and Discussion

Table 1 presents the composition of various spray gel formulations, each designed with a specific combination of ingredients and their respective concentrations; *Cordyline fruticosa* L. leaf extract: This is the active ingredient derived from the Andong Merah plant, known for its potential therapeutic properties. It's maintained at a constant 15% concentration across all formulations (F1, F2, F3) to isolate the impact of other varying components; Carbopol 940: This is a gelling agent, crucial for providing the gel-like consistency to the spray. Its concentration is varied across the formulations (0.4% in F1, 0.6% in F2, 0.8% in F3). This variation likely aims to study how different Carbopol 940 concentrations affect the gel's properties, such as viscosity, spreadability, and stability; Sorbitol (liquid): A humectant, sorbitol helps retain moisture and prevents the gel from drying out. Similar to Carbopol 940, its concentration also varies (5% in F1, 7.5% in F2, 10% in F3), suggesting an investigation into its influence on the final gel's characteristics; Triethanolamine: This compound is often used to neutralize Carbopol, ensuring the gel forms its desired structure. It's kept constant (1.2%) across all formulations, indicating it's not a primary focus of the study's variation; Methylparaben: A common preservative, methylparaben prevents microbial growth, ensuring the gel's safety and shelf-life. Its constant 0.09% concentration across formulations suggests it plays a standard preservative role rather than being a variable under investigation; Purified water: This acts as the solvent, forming the base in which all other ingredients are dissolved or dispersed. It's maintained at 100% in all formulations, likely indicating that the percentages of other ingredients are relative to the total volume of purified water used.

Table 1. The compositions of the formulations.

Material	K(-)	F1 (%)	F2 (%)	F3 (%)
Cordyline fruticosa L. leaf extract	-	15	15	15
Carbopol 940	0.6	0.4	0.6	0.8
Sorbitol (liquid)	7.5	5	7.5	10
Triethanolamine	1.2	1.2	1.2	1.2
Methylparaben	0.09	0.09	0.09	0.09
Purified water	100	100	100	100

K(-): negative control; F1: Formulation 1; F2: Formulation 2; F3: Formulation 3.

Table 2 outlines the tests conducted to identify various phytochemicals present in the *Cordyline fruticosa* L. leaf extract; Alkaloids: These are naturally occurring organic compounds with diverse physiological effects. The extract was subjected to three different tests (Mayer's, Dragendorff's, and Wagner's tests) which all rely on the reaction of alkaloids with specific reagents to produce precipitates. The formation of precipitates in all these tests confirms the presence of alkaloids in the extract; Flavonoids: Known for their antioxidant and anti-inflammatory properties, flavonoids were identified using the Shinoda Test and the Alkaline Reagent Test. A pink or red color in the Shinoda test and a yellow color intensified by acid in the Alkaline Reagent Test indicate the presence of flavonoids; Tannins: These compounds have astringent properties and can contribute to wound healing. The Ferric Chloride Test (indicated by a bluish-black or greenish-black color) and the Gelatin Test (formation of a precipitate) both confirm the presence of tannins in the extract; Steroids: This class of compounds has diverse biological functions, including roles in cell signaling and structure. The Liebermann-Burchard Test (green or blue-green color) and the Salkowski Test (reddish-brown in the chloroform layer) were used to confirm the presence of steroids; Saponins: These compounds have soap-like properties and can form stable foams. The Foam Test, where persistent foaming indicates the presence of saponins, confirms their presence in the extract.

Table 2. The phytochemical screening of the *Cordyline fruticosa* L. leaf extract.

Phytochemical test	Observation	Inference
Alkaloids	Mayer's Test: Formation of a white precipitate	Presence of alkaloids
	Dragendorff's Test: Formation of an orange-red precipitate	Presence of alkaloids
	Wagner's Test: Formation of a reddish-brown precipitate	Presence of alkaloids
Flavonoids	Shinoda Test: Formation of a pink or red color	Presence of flavonoids
	Alkaline Reagent Test: Formation of a yellow color that intensifies upon the addition of acid	Presence of flavonoids
Tannins	Ferric Chloride Test: Formation of a bluish-black or greenish-black color	Presence of tannins
	Gelatin Test: Formation of a precipitate	Presence of tannins
Steroids	Liebermann-Burchard Test: Formation of a green or blue-green color	Presence of steroids
	Salkowski Test: Formation of a reddish-brown color in the chloroform layer	Presence of steroids
Saponins	Foam Test: Formation of a persistent foam that lasts for at least 1 minute	Presence of saponins

Table 3 provides the results of an organoleptic evaluation, essentially a sensory assessment, of three different spray gel formulations (F1, F2, and F3) containing *Cordyline fruticosa* leaf extract. All three formulations (F1, F2, and F3) have a dark green color. This suggests that the variations in the concentration of the gelling agent (Carbopol 940) and the humectant (sorbitol) did not significantly affect the color of the final product. The dark green color likely comes from the *Cordyline fruticosa* leaf extract itself. Similarly, the odor is consistent across all formulations, described as a "characteristic herbal odor." This indicates that the primary source of the odor is the leaf extract, and the other ingredients do not have a strong odor of their own. This is where we see a difference in consistency between the formulations. F1 is described as "slightly runny," suggesting a lower viscosity. This is likely due to the lower concentration of Carbopol 940 and sorbitol in this formulation. F2 has an "intermediate" consistency, indicating a medium viscosity, probably due to the intermediate concentrations of Carbopol 940 and sorbitol. F3 is "thick, viscous," implying the highest viscosity among the three. This is consistent with the higher concentrations of Carbopol 940 and sorbitol in this formulation.

Table 3. The organoleptic evaluation of the *Cordyline fruticosa* L. leaf extract spray gel formulations.

Formulation	Color	Odor	Consistency
F1	Dark green	Characteristic herbal odor	Slightly runny
F2	Dark green	Characteristic herbal odor	Intermediate
F3	Dark green	Characteristic herbal odor	Thick, viscous

Table 4 shows the results of a homogeneity test conducted on three different formulations (F1, F2, and F3) of a spray gel containing *Cordyline fruticosa* leaf extract. The purpose of a homogeneity test is to ensure that the ingredients in a formulation are evenly distributed throughout the mixture. The observation for all three formulations is "Homogeneous, no visible clumps or aggregates." This means that when visually inspected, each formulation appeared to be a uniform mixture. There were no noticeable lumps, clumps, or unevenly distributed particles. Homogeneity is crucial in topical formulations like gels for several reasons; Consistent Dosing: It ensures that each application of the spray delivers a consistent amount of the active ingredient (*Cordyline fruticosa* extract) and other components; Even Spreading: A homogeneous mixture will spread more evenly on the skin, providing uniform coverage and potentially better absorption; Reduced Irritation: Clumps or aggregates in the gel could potentially cause skin irritation or discomfort. A homogeneous mixture minimizes this risk. The results indicate that all three formulations were successfully prepared, with the ingredients properly dispersed and mixed to achieve a uniform consistency. This is a positive outcome, suggesting good manufacturing practices and careful formulation design.

Table 4. The homogeneity test for the *Cordyline fruticosa* L. leaf extract spray gel formulations.

Formulation	Observation
F1	Homogeneous, no visible clumps or aggregates
F2	Homogeneous, no visible clumps or aggregates
F3	Homogeneous, no visible clumps or aggregates

Table 5 shows the pH values of three different *Cordyline fruticosa* L. leaf extract spray gel formulations (F1, F2, and F3) measured over a 21-day storage period. On Day 1, the formulations have slightly different pH values, ranging from 6.3 to 6.5. This initial difference is likely due to the varying concentrations of Carbopol 940 and sorbitol, which can influence the acidity or alkalinity of the formulation. The pH of each formulation gradually decreases over the 21-day storage period. Some components in the formulation might undergo hydrolysis, producing acidic byproducts that lower the pH. There might be a slight interaction between the formulation and the storage container, leading to the release of substances that affect the pH. Even with sealed containers, minimal exposure to air over time could introduce carbon dioxide, which dissolves in the gel and forms carbonic acid, slightly lowering the pH. The skin's natural pH is slightly acidic. Formulations with a pH that is too high or too low can disrupt the skin's barrier function, potentially leading to irritation or dryness. The pH can affect the stability and shelf-life of the formulation. Some ingredients might degrade or lose their activity at certain pH levels. The pH can influence the solubility and permeability of drugs, affecting their absorption through the skin. Although there's a slight decrease in pH over time, the values remain within the generally acceptable range for topical formulations (typically between 5 and 7). This suggests that the formulations are relatively stable in terms of pH and are likely to be compatible with the skin.

Table 5. The results of the pH measurements of the *Cordyline fruticosa* L. leaf extract spray gel formulations over a 21-day storage period.

Formulation	**Day 1**	**Day 7**	**Day 14**	**Day 21**
F1	6.3	6.2	6.1	6.0
F2	6.4	6.3	6.2	6.1
F3	6.5	6.4	6.3	6.2

Table 6 provided the viscosity of three different formulations (F1, F2, and F3) of a spray gel containing *Cordyline fruticosa* leaf extract, measured over 21 days in decipascal-seconds (dPas). On Day 1, the formulations show different viscosity values (F1 - 8.6 dPas, F2 - 9.5 dPas, F3 - 10.7 dPas). This variation is likely due to the different concentrations of Carbopol 940 and sorbitol. Higher concentrations of these ingredients generally lead to increased viscosity in gel formulations. For all formulations, there's a slight decrease in viscosity over the 21 days. This could be due to a few factors; The gelling agent (Carbopol 940) might undergo some degradation over time, affecting its ability to maintain the gel's structure and viscosity; The interactions between the gel's components (extract, gelling agent, humectant, etc.) might change slightly over time, influencing the overall viscosity; Even small temperature variations during storage can affect the viscosity of gels. Viscosity is a key characteristic in topical gels, influencing; Spreadability: How easily the gel spreads on the skin; Adhesion: How well the gel sticks to the skin's surface; Drug Release: The rate at which the active ingredient is released from the gel and absorbed into the skin. While a slight decrease is observed, the viscosity values remain within an acceptable range for topical gels throughout the 21 days. This suggests that the formulations maintain reasonable physical stability in terms of viscosity.

Table 6. The results of the viscosity measurements of the *Cordyline fruticosa* L. leaf extract spray gel formulations over a 21-day storage period.

Formulation	Day 1 (dPas)	Day 7 (dPas)	Day 14 (dPas)	Day 21 (dPas)
F1	8.6	8.4	8.2	8.0
F2	9.5	9.3	9.1	8.9
F3	10.7	10.5	10.3	10.1

Table 7 illustrates the spray patterns of three different formulations (F1, F2, F3) of a *Cordyline fruticosa* leaf extract spray gel when sprayed from varying distances. As the distance between the spray nozzle and the target surface increases, the diameter of the spray pattern also increases for all formulations. This is expected, as the spray has more space to disperse before reaching the surface. At the same distance, the formulations show some variation in the diameter of the spray pattern. This difference is likely related to the viscosity of each formulation, which is influenced by the concentrations of Carbopol 940 and sorbitol. F1, with the lowest viscosity, generally has the smallest spray diameter. F3, with the highest viscosity, tends to have the largest spray diameter. The spray pattern is important for topical applications as it affects; A wider spray pattern that covers a larger area with each spray; A consistent, even spray pattern ensures uniform distribution of the active ingredient on the skin; The spray pattern can influence how easy it is to apply the gel to the desired area. The ideal spray pattern depends on the intended use of the product. For example, a wider spray pattern might be preferred for covering large areas, while a narrower pattern might be more suitable for targeted applications.

Table 7. The results of the spray pattern analysis of the *Cordyline fruticosa* L. leaf extract spray gel formulations.

Formulation	Distance from nozzle (cm)	Diameter of spray pattern (cm)
F1	3	6.1
F1	5	10.4
F1	10	11.7
F2	3	7.5
F2	5	10.7
F2	10	12.3
F3	3	9.1
F3	5	10.8
F3	10	12.7

Table 8 provided the results of an adhesion test, measured in seconds, for three different formulations (F1, F2, and F3) of a spray gel containing *Cordyline fruticosa* leaf extract over a 21-day period. On Day 1, the formulations show different adhesion times (F1 - 11.8 seconds, F2 - 12.8 seconds, F3 - 13.1 seconds). This variation is likely due to the different concentrations of Carbopol 940 and sorbitol. Higher concentrations of these ingredients generally lead to increased viscosity and, consequently, better adhesion in gel formulations. For all formulations, there's a slight decrease in adhesion time over the 21 days. The gel's structure might undergo slight changes over time, affecting its adhesive properties. Some of the

humectant (sorbitol) might evaporate, reducing the gel's ability to bind to the skin. Exposure to air and moisture, even in sealed containers, could affect the gel's adhesive properties. Adhesion is important for topical formulations as it; Ensures the gel stays in contact with the skin for a longer duration, allowing better absorption of the active ingredient; Better adhesion can lead to more efficient delivery of the active ingredient to the skin; A gel that adheres well to the skin is more convenient for the user, potentially improving compliance with the treatment. While a slight decrease is observed, the adhesion times remain within a reasonable range for topical gels throughout the 21 days. This suggests that the formulations maintain adequate adhesive properties for effective application.

Table 8. The results of the adhesion test of the *Cordyline fruticosa* L. leaf extract spray gel formulations over a 21-day storage period.

Formulation	Day 1 (seconds)	Day 7 (seconds)	Day 14 (seconds)	Day 21 (seconds)
F1	11.8	11.6	11.3	11.0
F2	12.8	12.5	11.8	11.3
F3	13.1	12.4	12.2	12.0

This research delved into the formulation and physicochemical evaluation of a spray gel containing *Cordyline fruticosa* leaf extract, a plant known for its therapeutic potential, particularly in wound healing. The study focused on understanding how varying concentrations of Carbopol 940 (gelling agent) and sorbitol (humectant) influence the properties of the spray gel. The phytochemical screening of the *Cordyline fruticosa* leaf extract revealed the presence of various bioactive compounds, including alkaloids, flavonoids, tannins, steroids, and saponins. This finding is significant as it supports the traditional use of this plant in treating various ailments, including wounds. Alkaloids compounds are known for their analgesic, anti-inflammatory, and antimicrobial properties, which can aid in wound healing by reducing pain, inflammation, and infection risk. Flavonoids potent antioxidants protect cells from damage, reduce inflammation, and promote collagen synthesis, all of which are essential for wound healing. Tannins astringent and antimicrobial properties contribute to wound healing by constricting blood vessels, reducing bleeding, and preventing infection. Steroids compounds have anti-inflammatory effects, which can help to reduce swelling and pain associated with wounds. Saponins compounds have been shown to promote cell proliferation and migration, essential processes in tissue regeneration and wound healing. The presence of these diverse phytochemicals in the *Cordyline fruticosa* leaf extract suggests its potential as a therapeutic agent for topical applications, particularly in wound healing.[11-13]

The study involved formulating three different spray gel formulations (F1, F2, and F3) with varying concentrations of Carbopol 940 and sorbitol. The formulations were then subjected to a series of physicochemical evaluations to assess their quality and suitability for topical use. All three formulations exhibited a dark green color and a characteristic herbal odor, both attributed to the *Cordyline fruticosa* leaf extract. The consistency of the formulations varied, with F1 being slightly runny, F2 having an intermediate consistency, and F3 being thick and viscous. This variation is directly related to the concentrations of Carbopol 940 and sorbitol, highlighting their role in determining the gel's texture and spreadability. All formulations were found to be homogeneous, indicating a uniform distribution of ingredients throughout the gel. This is crucial for ensuring consistent dosing and preventing localized areas of high concentration that could potentially irritate the skin. The pH values of all formulations were

within the acceptable range for topical applications (5.0 - 7.0). This is important for skin compatibility, as formulations with extreme pH values can disrupt the skin's natural barrier, leading to irritation or dryness. The slight decrease in pH over the 21-day storage period suggests potential interactions between the formulation and its environment, which warrants further investigation. The viscosity of the formulations varied according to the concentrations of Carbopol 940 and sorbitol, with higher concentrations resulting in higher viscosity. This is expected, as these excipients are crucial for determining the gel's flow properties. The slight decrease in viscosity over time could be due to changes in the gel structure or interactions between its components. The spray pattern analysis revealed that the diameter of the spray pattern increased with increasing distance from the nozzle, which is consistent with the expected behavior of sprayable formulations. The variations in spray patterns between formulations are likely due to differences in viscosity, which affects the dispersion of the gel upon spraying. The adhesion test demonstrated that formulations with higher concentrations of Carbopol 940 and sorbitol exhibited better adhesion to the skin. This is significant as good adhesion ensures prolonged contact time between the formulation and the skin, allowing for better absorption of the active ingredient and potentially enhancing therapeutic efficacy.[14-18]

The findings of this study have significant implications for the development of topical formulations containing *Cordyline fruticosa* leaf extract. The results demonstrate that the extract can be successfully incorporated into a spray gel with acceptable physicochemical properties. The study also highlights the importance of carefully selecting and optimizing the concentrations of excipients, such as Carbopol 940 and sorbitol, to achieve the desired characteristics in the final formulation. The spray gel formulation offers several advantages over conventional topical formulations, such as ease of application, even distribution, and reduced risk of contamination. These benefits, coupled with the therapeutic potential of the *Cordyline fruticosa* leaf extract, make this spray gel a promising candidate for further investigation and development as a topical treatment option.[19,20]

4. Conclusion

This study successfully formulated and evaluated spray gel formulations containing *Cordyline fruticosa* leaf extract, with varying concentrations of Carbopol 940 and sorbitol. The prepared spray gels exhibited acceptable organoleptic properties, homogeneity, pH, and spray patterns. The viscosity and adhesion properties were influenced by the concentrations of Carbopol 940 and sorbitol, allowing for customization based on desired application requirements. The spray gel formulations demonstrated good physicochemical qualities, indicating their potential suitability for topical delivery of *Cordyline fruticosa* leaf extract. Further studies, including stability testing, in vitro and in vivo release studies, skin irritation tests, and clinical trials are recommended to further evaluate the long-term stability, efficacy, and safety of these formulations.

5. References

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