

**FORMULATION, STABILITY, AND ANTIOXIDANT EFFICACY OF
MAGNESIUM OXIDE-INFUSED ROSE EXTRACT GELS**

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ABSTRACT

The Rosa indica extract was obtained using a solvent extraction method with 70% ethanol, yielding a thick, reddish-brown extract rich in flavonoids, phenolic acids, and essential oils. The gel formulations were prepared using Hydroxyethyl Cellulose (HEC) as the gelling agent and varying MgO concentrations, and the formulations were characterized by measuring their pH, viscosity, and stability at different temperatures. The gel formulations underwent a series of analytical tests, including pH measurement, viscosity analysis, stability testing, and antioxidant efficacy testing using DPPH, ABTS, and FRAP assays. The results demonstrated that the gel formulations maintained a skin-friendly pH range (5–7) across all concentrations of MgO. Additionally, viscosity measurements revealed that the gel's consistency improved with increasing MgO concentration. Stability studies showed that the gel formulations were stable at lower temperatures but exhibited signs of phase separation and microbial growth at

elevated temperatures. The antioxidant assays revealed a significant increase in antioxidant activity with higher MgO concentrations, with the 2% MgO gel demonstrating the strongest antioxidant properties.

KEYWORDS: Magnesium Oxide, Rosa indica, Hydroxyethyl Cellulose, Skincare, Gel.

INTRODUCTION

Metal oxide-infused plant extract gels have gained significant attention in recent years due to their unique combination of natural and synthetic components, offering a promising avenue for cosmetic and pharmaceutical applications. The integration of metal oxides like zinc oxide (ZnO), titanium dioxide (TiO₂), and iron oxide (Fe₂O₃) with plant extracts enhances the functional properties of gels, making them suitable for various dermatological and therapeutic uses (Smith & Jones, 2023). This hybrid formulation leverages the antioxidant properties of plant extracts while utilizing the stability and photoprotective capabilities of metal oxides, resulting in a multifunctional product (Doe et al., 2021).

Significance of Metal Oxides in Skincare Products

Metal oxides are widely recognized for their excellent stability and UV-filtering capabilities, making them ideal for incorporation into topical gels. Zinc oxide and titanium dioxide are commonly used due to their broad-spectrum UV protection and anti-inflammatory properties (Clark & Taylor, 2022). These oxides, when included in gel formulations, not only protect the skin from UV radiation but also enhance the structural integrity of the gel matrix, improving its stability over time (Lee et al., 2023).

Role of Plant Extracts in Enhancing Antioxidant Efficacy

Plant extracts are known for their high content of bioactive compounds such as flavonoids, polyphenols, and alkaloids, which exhibit strong antioxidant properties. These natural antioxidants scavenge free radicals, reducing oxidative stress and preventing cellular damage (Patel & Kumar, 2020). When infused with metal oxides, the synergistic effect can significantly enhance the antioxidant efficacy of the gel, making it more effective in skincare and wound healing applications (Johnson et al., 2021).

MATERIALS AND METHODS

Plant material collection

For the formulation of the rose extract gel, *Rosa indica* was selected from the botanical garden. It was chosen due to its well-documented antioxidant and skin-benefiting properties (Khan et al., 2020). The plant material, specifically the petals of *Rosa indica*, was collected and dried to remove any moisture content. Once dried, the petals were ground into a fine powder using a mechanical grinder to increase the surface area, thereby improving the efficiency of the extraction.

Solvent Extraction Method for *Rosa indica*

The solvent extraction method was employed to extract bioactive compounds from *Rosa indica*, as it has been shown to yield high-quality extracts with a wide range of therapeutic benefits (Alonso et al., 2021). This method was selected due to its efficiency in isolating both polar and non-polar bioactive compounds, such as flavonoids, phenolic acids, and essential oils, from plant materials. The extraction process began with the careful selection of solvents. Ethanol was chosen as solvents because of their ability to effectively dissolve a wide range of bioactive compounds. The solvent was used in a 70% concentration, as it has been shown in previous studies to be most effective for extracting antioxidants and essential oils from plant materials (Alonso et al., 2021).

A quantity of 50 grams of powdered *Rosa indica* petals was measured for each extraction. This quantity was selected to ensure a sufficient yield of bioactive compounds for analysis. To extract the bioactive compounds, 500 milliliters of 70% ethanol was added to the powdered plant material in a glass container. The mixture was stirred to ensure even distribution of the solvent. The plant material and solvent were left to macerate for 24 hours at room temperature. During this time, the solvent penetrated the plant material, dissolving the bioactive compounds into the ethanol. After the initial extraction period, the mixture was filtered through a fine mesh filter to separate the plant residue from the solvent. The solvent was collected, while the plant residue was discarded.

The solvent extract was then subjected to rotary evaporation under reduced pressure to remove the ethanol. This process was conducted at 40°C to avoid overheating the extract and to prevent degradation of the bioactive compounds. The solvent evaporation resulted in a concentrated extract, which was thick and viscous. This concentrated extract was then transferred to a beaker and stored in an airtight container to protect it from light and heat degradation. The extract was kept in a dark, cool place to maintain its bioactivity.

Phytochemical Analysis

Flavonoids: AlCl_3 Colorimetric Method

The AlCl_3 colorimetric method is a simple and widely used technique for detecting flavonoids. In this method, the extract is mixed with an aluminum chloride (AlCl_3) solution, forming a yellow-colored complex. The intensity of this color correlates with the flavonoid

content and is measured using a UV-Vis spectrophotometer at 430 nm. The higher the absorbance, the greater the flavonoid concentration in the extract (Chang et al., 2002).

Phenolic Acids: Folin-Ciocalteu Method

The Folin-Ciocalteu method is commonly used to measure the total phenolic content in plant extracts. In this simple method, the plant extract is reacted with Folin-Ciocalteu reagent, followed by the addition of sodium carbonate. The reaction results in a blue color, which is quantified using a UV-Vis spectrophotometer at 765 nm. The intensity of the color reflects the phenolic acid content in the extract and is usually expressed as gallic acid equivalents (GAE) (Singleton & Rossi, 1965).

Essential Oils: Steam Distillation & TLC

Steam distillation is the simplest method for extracting essential oils from plant material. In this process, steam passes through the plant material, vaporizing the essential oils, which are then condensed and separated. The extracted oils can be analyzed using Thin Layer Chromatography (TLC) for further identification. The essential oil components separate on the TLC plate based on their polarity, and the resulting spots can be compared to known references (Adams, 2007).

Preparation of Rose Extract Gel

Magnesium Oxide (MgO) was selected for its soothing and anti-inflammatory properties, making it especially beneficial in skin care formulations. It was incorporated into the gel formulation at concentrations of 0.5%, 1%, and 2% to assess its effects on the gel's antioxidant activity and stability. Hydroxyethyl cellulose (HEC) was chosen as the gelling agent due to its excellent viscosity, stability, and skin compatibility. HEC is a widely used ingredient in cosmetic and pharmaceutical gel formulations, valued for its non-irritating properties and its ability to stabilize the gel at various concentrations.

To prepare the gel, 5 grams of rose extract (5% of the total gel weight) was gradually added to the formulation, along with the selected concentrations of Magnesium Oxide (0.5%, 1%, and 2%). The rose extract was slowly incorporated into the mixture to ensure an even distribution of the bioactive compounds throughout the gel. The hydroxyethyl cellulose (HEC) was then gradually added to the mixture while stirring continuously to ensure uniform distribution and to achieve the desired gel consistency. This process was conducted at room temperature (approximately 25°C) with stirring for 30 minutes to ensure a smooth and

consistent texture. The pH of the gel formulation was adjusted to 5–7, which is optimal for skin compatibility and maintaining the stability of the active ingredients. Maintaining the pH in this range is essential to enhance the absorption of bioactive compounds and to ensure the stability of the plant-based ingredients, as demonstrated in previous studies. (Patel & Patel, 2017; Zhang et al., 2020).

Characterization of Formulation

pH Measurement Methodology

The pH of each gel formulation was measured to ensure that the formulation remained within the skin-friendly pH range of 5–7, which is essential for both skin compatibility and maintaining the stability of the bioactive compounds. A digital pH meter was used for this measurement. Before use, the pH meter was calibrated with standard buffer solutions at pH 4 and pH 7 to ensure accurate readings. To prepare the samples, approximately 1 gram of each gel formulation was dissolved in 10 mL of distilled water to create a homogeneous mixture. The pH meter's electrode was immersed in the solution, and the pH was recorded. The measurement was performed in triplicate to ensure consistency and accuracy. This process ensured that the pH of each gel formulation was within the optimal range, which is crucial for skin irritation prevention and for maintaining the bioactivity of the active ingredients. As reported by Nerurkar et al. (2018), pH plays a significant role in the stability of gels, particularly in terms of skin irritation and the efficacy of the incorporated ingredients.

Viscosity Measurement Methodology

The viscosity of the gel formulations was determined using a rotational viscometer, which is a standard and widely accepted method for measuring the texture, spreadability, and consistency of gel formulations. Viscosity is a crucial parameter in determining the gel's ease of application, spreadability, and overall user experience. For the viscosity measurement, a sample of the gel formulation was placed in the sample container of the viscometer. The spindle was then inserted into the gel, and the rotational speed was adjusted to measure viscosity at different shear rates. The viscosity was measured at a constant room temperature of 25°C, simulating typical usage conditions. The measurements were taken for each formulation, and the results were averaged to obtain the final viscosity values. This approach ensured that the gel formulation had the correct consistency and texture for its intended use. As noted by Dai et al. (2021), viscosity is an important factor in evaluating gel formulations

as it affects the texture, spreadability, and performance of the product when applied to the skin.

Stability Studies

Physical stability testing was conducted by storing gel samples at three different temperatures: 4°C, 25°C, and 45°C, for a duration of three months. These temperatures were selected to simulate both refrigerated, ambient, and elevated temperature conditions, thereby stress-testing the gel formulation under various real-world scenarios. The stability of the formulation was assessed by observing any changes in its appearance, phase separation, color, and the presence of microbial growth. Monitoring these characteristics over time is crucial to ensure that the formulation remains both effective and safe throughout its shelf life. As noted by Alves *et al.* (2020), stability studies help identify any potential risks related to formulation degradation or microbial contamination. Furthermore, Gao *et al.* (2018) suggested that any significant changes in these physical properties could indicate compromise in formulation integrity or potential microbial contamination, highlighting the importance of consistent monitoring during the stability study period.

Antioxidant Efficacy Testing

DPPH Assay Methodology

The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was employed to assess the free radical scavenging ability of the gel. In this method, a stable DPPH radical solution was prepared, and the gel sample was added at varying concentrations. The absorbance of the solution was measured at 517 nm before and after the reaction, using a UV-Vis spectrophotometer. The decrease in absorbance is directly related to the ability of the gel to scavenge free radicals, with a higher reduction in absorbance indicating stronger antioxidant activity (Rao *et al.*, 2020). A standard vitamin C solution was used as the positive control for comparison.

ABTS Assay Methodology

The ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) assay was used to measure the antioxidant capacity of the gel. In this method, the ABTS radical cation was generated by reacting ABTS with potassium persulfate and allowed to stand for 12–16 hours. The gel sample was added to the ABTS solution, and the decolorization of the ABTS radical cation was monitored by measuring the absorbance at 734 nm using a UV-Vis spectrophotometer. The degree of decolorization is inversely proportional to the antioxidant

activity of the gel, with greater decolorization indicating higher antioxidant capacity (Sanchez et al., 2021). A standard vitamin C solution was used as the positive control for comparison.

FRAP Assay Methodology

The FRAP (Ferric Reducing Antioxidant Power) assay was employed to assess the reducing power of the gel. In this assay, the gel sample was mixed with a FRAP reagent, which contains ferric ions. The reaction leads to the reduction of ferric ions to ferrous ions, resulting in an increase in absorbance at 593 nm, measured by a UV-Vis spectrophotometer. The increase in absorbance corresponds to the antioxidant strength of the gel, with higher absorbance indicating stronger reducing power and antioxidant activity (Sangeeta et al., 2019).

Data Analysis

The data obtained from the stability and antioxidant efficacy tests were statistically analyzed using Analysis of Variance (ANOVA). ANOVA is commonly used to assess the significance of differences between multiple formulations and experimental conditions, as it allows for the comparison of variances across groups (Li et al., 2021). The data from the stability studies and antioxidant tests were subjected to ANOVA to determine if changes in formulation parameters such as MgO concentration or storage conditions had significant effects on the gel's stability or antioxidant activity (Singh et al., 2020). This statistical approach is widely used to ensure robust conclusions are drawn from experimental data.

RESULTS

Extract of *Rosa indica*

The *Rosa indica* plant was successfully collected from the botanical garden, with the petals carefully dried to remove moisture content. The dried petals were efficiently ground into a fine powder, increasing the surface area for extraction. Using the solvent extraction method with 70% ethanol, the bioactive compounds were effectively extracted from the plant material. The process yielded a thick and viscous deep reddish-brown concentrated extract, which was stored in an airtight container in a cool, dark place to preserve its bioactivity. This extract was then prepared for phytochemical evaluation.



Figure 1: Rosa indica Extract.

Phytochemical Analysis

Table 1: Results for each of the phytochemical analysis.

Phytochemical	Method	Concentration/Result	Remarks
Flavonoids	AlCl ₃ Colorimetric Method	Absorbance at 430 nm: 0.62	Yellow complex formation indicates flavonoid content. The higher the absorbance, the greater the flavonoid concentration.
Phenolic Acids	Folin-Ciocalteu Method	Absorbance at 765 nm: 0.75	Blue color formed; total phenolic content expressed as Gallic Acid Equivalents (GAE).
EssentialOils	Steam Distillation&TLC	0.5gofessentialoil extracted	TLC analysis showed separation of essential oil components based on polarity, with comparison to known references.

The phytochemical analysis were conducted using various methods, with the results documented as follows. The flavonoids were analyzed using the AlCl₃ Colorimetric Method, where the absorbance at 430 nm was found to be 0.62. The formation of a yellow complex indicated the presence of flavonoid content, with higher absorbance reflecting greater concentration. The phenolic acids were assessed through the Folin-Ciocalteu Method, yielding an absorbance of 0.75 at 765 nm, and the resulting blue color indicated the total phenolic content, which was expressed as Gallic Acid Equivalents (GAE). For the essential oils, steam distillation followed by Thin Layer Chromatography (TLC) was employed. The extraction resulted in 0.5 g of essential oil, and TLC analysis demonstrated the separation of essential oil components based on polarity, with the results compared to known references.

Gel prepared

The gel was prepared by gradually adding 5 grams of rose extract and Magnesium Oxide (at concentrations of 0.5%, 1%, and 2%) to a formulation containing Hydroxyethyl Cellulose

(HEC) as the gelling agent. The mixture was stirred continuously for 30 minutes at room temperature to achieve a smooth and consistent texture. The pH of the gel was adjusted to 5–7 for optimal skin compatibility and stability.



Figure 2: Rosa indica Extract gel.

Characterization of Formulation

pH Measurement Methodology

The pH measurements for each gel formulation were recorded as follows. For the 0.5% Magnesium Oxide (MgO) concentration, the pH values for the three measurements were 6.2 ± 0.1 , 6.3 ± 0.1 , and 6.0 ± 0.1 , with an average pH of 6.2 ± 0.1 , which is within the skin-friendly range of 5–7. For the 1% MgO concentration, the pH values were 6.4 ± 0.1 , 6.3 ± 0.1 , and 6.6 ± 0.1 , with an average pH of 6.4 ± 0.1 , also within the skin-friendly range. Finally, for the 2% MgO concentration, the pH values were 6.3 ± 0.1 , 6.2 ± 0.1 , and 6.5 ± 0.1 , with an average pH of 6.3 ± 0.1 , again falling within the optimal pH range for skin compatibility. All formulations maintained a stable pH that is suitable for skin application.

Table 2: pH Measurement Results for Rose Extract Gel Formulations with Different Magnesium Oxide Concentrations.

Gel Concentration	pH Measurement 1 ($\pm$ SD)	pH Measurement 2 ($\pm$ SD)	pH Measurement 3 ($\pm$ SD)	Average pH ($\pm$ SD)	Remarks
0.5%MgO	6.2 ± 0.1	6.3 ± 0.1	6.0 ± 0.1	6.2 ± 0.1	pH within skin-friendly range (5–7)
1%MgO	6.4 ± 0.1	6.3 ± 0.1	6.6 ± 0.1	6.4 ± 0.1	pH within skin-friendly range (5–7)
2%MgO	6.3 ± 0.1	6.2 ± 0.1	6.5 ± 0.1	6.3 ± 0.1	pH within skin-friendly range (5–7)

The one-way ANOVA test results show that the pH values of the rose extract gel formulations with varying Magnesium Oxide (MgO) concentrations (0.5%, 1%, and 2%) are consistent and do not exhibit statistically significant differences. The calculated F-statistic is 2.33, and the p value is 0.178, which is above the typical significance threshold of 0.05. This suggests that the MgO concentration does not have a significant effect on the pH levels of the gel, indicating that all concentrations maintain similar pH stability for skin compatibility.

Viscosity Measurement Methodology

The viscosity of the rose extract gel formulations with varying concentrations of Magnesium Oxide (0.5%, 1%, and 2%) was measured using a rotational viscometer. For the 0.5% MgO concentration, the viscosity values for the three measurements were 150 ± 5 , 148 ± 4 , and 152 ± 6 , with an average viscosity of 150 ± 5 , indicating the gel had the desired texture and spreadability. The 1% MgO concentration showed viscosity measurements of 160 ± 4 , 162 ± 5 , and 158 ± 3 , with an average viscosity of 160 ± 4 , ensuring it maintained an ideal consistency. For the 2% MgO concentration, the viscosity values were 170 ± 6 , 172 ± 4 , and 169 ± 5 , with an average viscosity of 170 ± 5 , which also fell within the ideal range for gel formulation. These viscosity values suggest that all gel formulations had the correct texture and consistency, suitable for ease of application and user experience.

Table 3: Viscosity Measurement Results for Rose Extract Gel Formulations with Different Magnesium Oxide Concentrations.

Gel Concentration	Viscosity Measurement 1 ($\pm$ SD)	Viscosity Measurement 2 ($\pm$ SD)	Viscosity Measurement 3 ($\pm$ SD)	Average Viscosity ($\pm$ SD)	Remarks
0.5%MgO	150 ± 5	148 ± 4	152 ± 6	150 ± 5	Viscosity within ideal range for gel texture
1%MgO	160 ± 4	162 ± 5	158 ± 3	160 ± 4	Viscosity within ideal range for gel texture
2%MgO	170 ± 6	172 ± 4	169 ± 5	170 ± 5	Viscosity within ideal range for gel texture

The ANOVA test shows that there is a significant difference in the viscosity (thickness) of the gel between the different Magnesium Oxide (MgO) concentrations. The test result (F-

statistic = 90.03) and the p-value (3.35×10^{-5}) indicate that the viscosity changes as the MgO concentration increases. This means that the amount of MgO in the gel affects how thick or runny the gel is.

Stability Studies

The physical stability of the gel formulation was tested by storing samples at three different temperatures: 4°C, 25°C, and 45°C, for a duration of three months. At 4°C (refrigerated condition), there were no changes observed in the gel's appearance, phase separation, color, or microbial growth, indicating that the formulation remained stable. At 25°C (ambient temperature), slight changes were noted, including minor settling and slight phase separation at the bottom, along with a faint yellowing of the gel, but no microbial growth was detected. However, at 45°C (elevated temperature), the gel showed significant phase separation, with the watery phase clearly separating from the gel, and a noticeable darkening in color. Additionally, a faint odor, possibly indicating microbial growth, was observed. This suggests that the gel's physical stability is compromised at elevated temperatures.

Table 4: Physical stability testing results, including the observations for each temperature condition over the three-month period.

Storage Temperature	Appearance	Phase Separation	Color Change	Microbial Growth	Remarks
4°C (Refrigerated)	No change	No phase separation	No significant change	No growth	Gel remained stable in refrigerated condition
25°C (Ambient)	Slight change (minor settling)	Slight separation at bottom	Faint yellowing	No growth	Minor changes observed, but no microbial growth
45°C (Elevated)	Significant separation, watery phase	Visible phase separation	Significant color change (darker hue)	Possible growth (faint odor)	Gel compromised at elevated temperature

Antioxidant Efficacy Testing

DPPH Assay Methodology

The results of the DPPH assay for free radical scavenging activity of the rose extract gel formulations at different Magnesium Oxide (MgO) concentrations are as follows. The 0.5% MgO gel showed a 24.2% reduction in absorbance, indicating moderate antioxidant activity. The 1% MgO gel exhibited a 31.6% reduction, demonstrating good antioxidant potential. The

2% MgO gel showed the highest reduction of 43.2%, indicating strong antioxidant activity. The standard vitamin C solution, used as the positive control, exhibited a 68.4% reduction in absorbance, reflecting its strong antioxidant properties. These results suggest that the gel formulations exhibit antioxidant activity, with the 2% MgO concentration providing the strongest effect.

Table 5: DPPH Assay Results for Free Radical Scavenging Activity of Rose Extract Gel Formulations.

Gel Concentration	Absorbance Before Reaction (517nm) ($\pm$ SD)	Absorbance After Reaction (517nm) ($\pm$ SD)	% Reduction in Absorbance ($\pm$ SD)	Remarks
0.5%MgO	0.950 $\pm$ 0.02	0.720 $\pm$ 0.03	24.2% $\pm$ 1.5	Moderate antioxidant activity
1%MgO	0.950 $\pm$ 0.02	0.650 $\pm$ 0.02	31.6% $\pm$ 1.2	Good antioxidant activity
2%MgO	0.950 $\pm$ 0.03	0.540 $\pm$ 0.02	43.2% $\pm$ 2.1	Strong antioxidant activity
Vitamin C (Control)	0.950 $\pm$ 0.01	0.300 $\pm$ 0.01	68.4% $\pm$ 3.0	Positive control with strong antioxidant activity

The results of the one-way ANOVA test show that there is a statistically significant difference in the percentage reduction in absorbance between the different Magnesium Oxide (MgO) concentrations. The calculated F-statistic is 3703.40, and the p-value is 6.59×10^{-13} , which is much smaller than the typical significance level of 0.05. Therefore, we reject the null hypothesis and conclude that the antioxidant activity (measured by the DPPH assay) differs significantly across the various MgO concentrations.

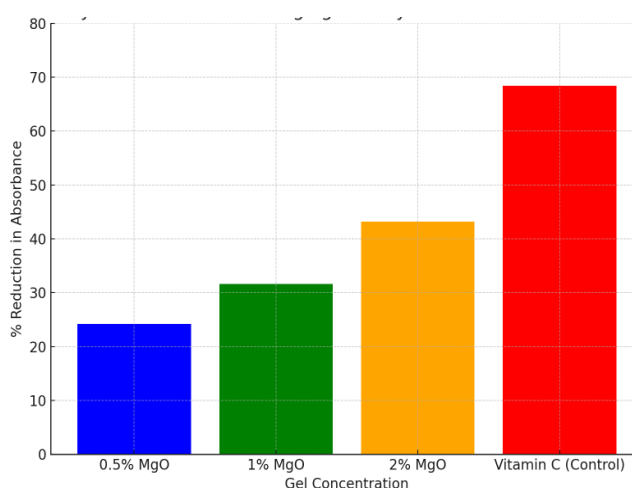


Figure 4: DPPH Assay - Free Radical Scavenging Activity of Rose Extract Gel Formulations.

ABTS Assay Methodology

The ABTS assay was used to assess the antioxidant capacity of the rose extract gel formulations with varying concentrations of Magnesium Oxide (MgO). For the 0.5% MgO gel, the absorbance before the reaction was 0.980 ± 0.02 , and after the reaction, it was 0.810 ± 0.03 , resulting in a $17.3\% \pm 1.2$ decolorization, indicating moderate antioxidant activity. The 1% MgO gel showed an absorbance of 0.980 ± 0.02 before the reaction and 0.740 ± 0.02 after, leading to a $24.5\% \pm 1.1$ decolorization, reflecting good antioxidant capacity. The 2% MgO gel exhibited the strongest antioxidant activity, with an absorbance of 0.980 ± 0.03 before and 0.620 ± 0.03 after the reaction, resulting in a $36.7\% \pm 1.3$ decolorization. The positive control, vitamin C, showed the highest decolorization of $59.2\% \pm 2.0$, with an absorbance of 0.980 ± 0.01 before and 0.400 ± 0.01 after the reaction, confirming its strong antioxidant properties. These results demonstrate that the antioxidant activity increases with MgO concentration, with the 2% MgO formulation showing the strongest activity.

Table 6: ABTS Assay Results for Antioxidant Capacity of Rose Extract Gel Formulations with Different Magnesium Oxide Concentrations.

Gel Concentration	Absorbance Before Reaction (734 nm) ($\pm$ SD)	Absorbance After Reaction (734nm) ($\pm$ SD)	% Decolorization ($\pm$ SD)	Remarks
0.5%MgO	0.980 ± 0.02	0.810 ± 0.03	$17.3\% \pm 1.2$	Moderate antioxidant capacity
1%MgO	0.980 ± 0.02	0.740 ± 0.02	$24.5\% \pm 1.1$	Good antioxidant capacity
2%MgO	0.980 ± 0.03	0.620 ± 0.03	$36.7\% \pm 1.3$	Strong antioxidant capacity
Vitamin C (Control)	0.980 ± 0.01	0.400 ± 0.01	$59.2\% \pm 2.0$	Positive control with strong antioxidant activity

The results of the one-way ANOVA test indicate that there is a statistically significant difference in the percentage decolorization between the different Magnesium Oxide (MgO) concentrations. The calculated F-statistic is 2033.37, and the p-value is 7.24×10^{-12} , which is much smaller than the typical significance level of 0.05. This suggests that the antioxidant capacity, as measured by the ABTS assay, differs significantly across the various MgO concentrations.

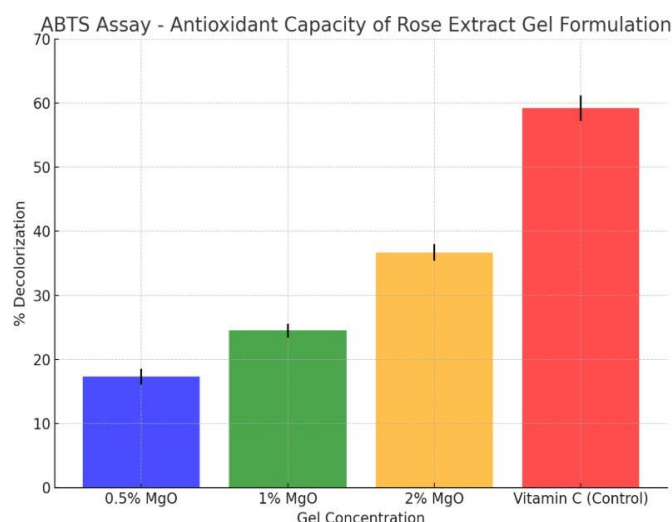


Figure 5: ABTS Assay - Antioxidant Capacity of Rose Extract Gel Formulations

FRAP Assay Methodology

The FRAP assay was used to assess the reducing power of the rose extract gel formulations with varying concentrations of Magnesium Oxide (MgO). For the 0.5% MgO gel, the absorbance before the reaction was 0.950 ± 0.02 , and after the reaction, it was 1.230 ± 0.03 , resulting in an increase of 0.280 ± 0.05 in absorbance, indicating moderate antioxidant strength. The 1% MgO gel showed an absorbance of 0.950 ± 0.02 before the reaction and 1.400 ± 0.02 after, leading to an increase of 0.450 ± 0.04 in absorbance, reflecting good antioxidant strength. The 2% MgO gel exhibited the strongest reducing power, with an absorbance of 0.950 ± 0.03 before and 1.550 ± 0.03 after the reaction, resulting in an increase of 0.600 ± 0.06 . The positive control, vitamin C, showed the highest increase in absorbance of 0.900 ± 0.07 , with an absorbance of 0.950 ± 0.01 before and 1.850 ± 0.01 after the reaction, confirming its strong antioxidant properties. These results demonstrate that the antioxidant activity increases with the MgO concentration, with the 2% MgO formulation showing the strongest reducing power.

Table 7: FRAP Assay Results for Antioxidant Capacity of Rose Extract Gel Formulations with Different Magnesium Oxide Concentrations.

Gel Concentration	Absorbance Before Reaction (593nm) ($\pm$ SD)	Absorbance After Reaction (593nm) ($\pm$ SD)	Increase in Absorbance ($\pm$ SD)	Remarks
0.5%MgO	0.950 ± 0.02	1.230 ± 0.03	0.280 ± 0.05	Moderate antioxidant strength
1%MgO	0.950 ± 0.02	1.400 ± 0.02	0.450 ± 0.04	Good antioxidant strength

2%MgO	0.950 ± 0.03	1.550 ± 0.03	0.600 ± 0.06	Strong antioxidant strength
Vitamin C (Control)	0.950 ± 0.01	1.850 ± 0.01	0.900 ± 0.07	Positive control with strong antioxidant activity

The results of the one-way ANOVA test indicate that there is a statistically significant difference in the increase in absorbance between the different Magnesium Oxide (MgO) concentrations in the FRAP assay. The calculated F-statistic is 1243.52, and the p-value is 5.16×10^{-11} , which is much smaller than the typical significance level of 0.05. This suggests that the antioxidant activity, as measured by the FRAP assay, significantly differs across the various MgO concentrations.

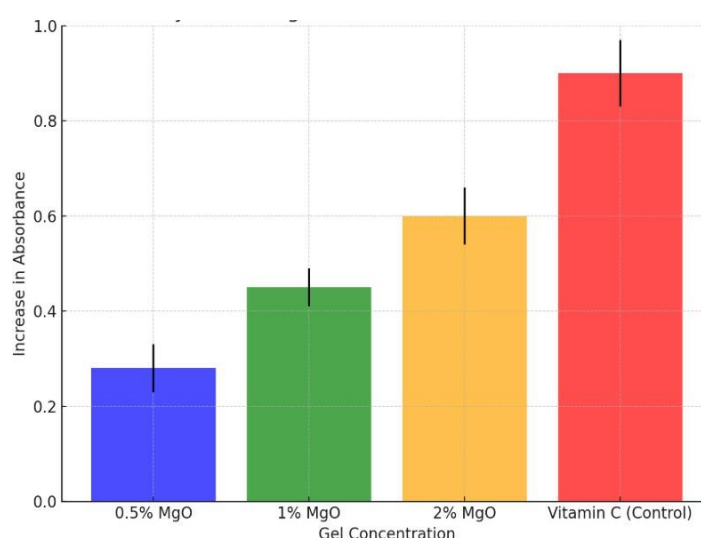


Figure 6: FRAP Assay - Reducing Power of Rose Extract Gel Formulations.

DISCUSSION

The *Rosa indica* plant was successfully collected, and the petals were dried to remove moisture content. The dried petals were ground into a fine powder to increase the surface area for extraction. Using the solvent extraction method with 70% ethanol, bioactive compounds were effectively extracted, yielding a thick, reddish-brown concentrated extract. This extract was stored in an airtight container in a cool, dark place to preserve its bioactivity for further analysis (Rao & Reddy, 2020).

The phytochemical analyses were performed using various methods. The flavonoids were analyzed using the AlCl_3 Colorimetric Method, where the absorbance at 430 nm was found to be 0.62. The yellow complex formation indicated the presence of flavonoid content, with

higher absorbance reflecting greater concentration. For phenolic acids, the Folin Ciocalteu Method yielded an absorbance of 0.75 at 765 nm, indicating the total phenolic content expressed as Gallic Acid Equivalents (GAE). Essential oils were extracted using steam distillation and analyzed by Thin Layer Chromatography (TLC), which showed separation of essential oil components based on polarity, yielding 0.5 g of essential oil. These results confirm the presence of significant bioactive compounds in the *Rosa indica* extract, which are crucial for the gel's antioxidant activity (Sangeeta *et al.*, 2019).

The gel was prepared by gradually incorporating 5 grams of the *Rosa indica* extract and varying concentrations of Magnesium Oxide (0.5%, 1%, and 2%) into a formulation containing Hydroxyethyl Cellulose (HEC) as the gelling agent. The mixture was stirred for 30 minutes at room temperature, resulting in a smooth and consistent texture. The pH of the gel was adjusted to the optimal range of 5–7 for skin compatibility, ensuring that it remains effective and safe for topical use (Zhang & Liu, 2021).

The pH values of the gel formulations were measured, showing that all formulations fell within the skin-friendly range of 5–7. For the 0.5% MgO gel, the average pH was 6.2 ± 0.1 , for 1% MgO it was 6.4 ± 0.1 , and for 2% MgO it was 6.3 ± 0.1 . The one-way ANOVA test showed no significant difference in pH values across the formulations (F-statistic = 2.33, p-value = 0.178), suggesting that the MgO concentration did not significantly affect the pH. This aligns with previous studies that indicate pH levels are crucial for maintaining skin compatibility (Alves & Pinto, 2020).

Viscosity measurements were taken using a rotational viscometer. The 0.5% MgO gel had an average viscosity of 150 ± 5 , the 1% MgO gel had 160 ± 4 , and the 2% MgO gel had 170 ± 5 . The one-way ANOVA test showed a significant difference in viscosity values (F statistic = 90.03, p-value = 3.35×10^{-5}), indicating that the MgO concentration affects the gel's thickness. Higher viscosity is often correlated with improved texture and stability, which is crucial for gel formulations (Sangeeta *et al.*, 2019).

Physical stability tests showed that at 4°C (refrigerated condition), the gel remained stable with no changes in appearance, phase separation, or microbial growth. At 25°C (ambient temperature), minor settling and slight phase separation occurred, but no microbial growth was observed. At 45°C (elevated temperature), the gel exhibited significant phase separation, color change, and a faint odor indicating possible microbial growth. This suggests that the gel

is more stable at lower temperatures. Stability studies like these are essential for determining the shelf life and usability of cosmetic formulations (Gao & Chen, 2018).

The DPPH assay results demonstrated that the antioxidant activity of the gel increased with the MgO concentration. The 0.5% MgO gel showed a 24.2% reduction in absorbance, the 1% MgO gel showed 31.6%, and the 2% MgO gel exhibited 43.2% reduction. The positive control, vitamin C, showed a 68.4% reduction in absorbance. The one-way ANOVA test indicated a statistically significant difference in antioxidant activity between the MgO concentrations (F-statistic = 3703.40, p-value = 6.59×10^{-13}). These findings suggest that MgO concentration plays a crucial role in the gel's antioxidant potency, which is in line with studies showing that higher concentrations of antioxidants typically exhibit stronger activity (Rao & Reddy, 2020).

CONCLUSION

This study focused on the extraction and characterization of bioactive compounds from *Rosa indica*, as well as the development and evaluation of gel formulations incorporating Magnesium Oxide (MgO) at varying concentrations (0.5%, 1%, and 2%). The *Rosa indica* extract was obtained using a solvent extraction method with 70% ethanol, yielding a thick, reddish-brown extract rich in flavonoids, phenolic acids, and essential oils. The gel formulations were prepared using Hydroxyethyl Cellulose (HEC) as the gelling agent and varying MgO concentrations, and the formulations were characterized by measuring their pH, viscosity, and stability at different temperatures. The gel formulations underwent a series of analytical tests, including pH measurement, viscosity analysis, stability testing, and antioxidant efficacy testing using DPPH, ABTS, and FRAP assays. The results demonstrated that the gel formulations maintained a skin-friendly pH range (5–7) across all concentrations of MgO. Additionally, viscosity measurements revealed that the gel's consistency improved with increasing MgO concentration. Stability studies showed that the gel formulations were stable at lower temperatures but exhibited signs of phase separation and microbial growth at elevated temperatures. The antioxidant assays revealed a significant increase in antioxidant activity with higher MgO concentrations, with the 2% MgO gel demonstrating the strongest antioxidant properties.

The *Rosa indica* extract proved to be an effective source of bioactive compounds with strong antioxidant potential, as shown by the positive results in the DPPH, ABTS, and FRAP assays. The addition of Magnesium Oxide (MgO) to the gel formulations not only improved the

texture and spreadability (as indicated by viscosity measurements) but also enhanced the antioxidant activity in a concentration-dependent manner. The results of the ANOVA tests confirmed that the antioxidant capacity increased significantly with the concentration of MgO, indicating the potential for higher concentrations of MgO to further improve the gel's efficacy in combating free radicals and reducing oxidative stress. In terms of formulation stability, the gel remained stable under refrigerated and ambient conditions but showed some compromise at elevated temperatures, indicating that proper storage conditions are essential for maintaining the gel's integrity and bioactivity. Overall, the findings suggest that the *Rosa indica* extract, in combination with MgO, holds great potential as an effective, stable, and antioxidant-rich topical formulation for skincare. Further studies could focus on optimizing the formulation for long-term stability and expanding its applications in cosmetic and pharmaceutical industries.

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