Journal of Advances in Allied Health Sciences Research (JAAHSR)
e-ISSN: XXX XXX
Vol. X, 2023
ORIGINAL RESEARCH ARTICLE

Banana (*Musa sapientum*) Peel Methanolic Extract Formulated as an Antioxidant Topical Gel

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***Abstract*— Banana plant, which is a very abundant plant in Cagayan soil, is one of the emerging potential sources of phenolic antioxidants in recent research. Reactive Oxygen Stress is a subset of free radicals that contain oxygen which have the potential to bind to and destroy cell components, causing skin dryness, wrinkles, and premature aging. This study aimed to determine the antioxidant activity of Banana (Musa sapientum) peel methanolic extract formulated as a topical gel through metal chelating, ABTS free radical scavenging, and DPPH assay. It was further subjected to physical property and bioassay tests. Among the three antioxidant testing, the different concentrations (25%, 50%, and 75%) of the gel formulation did not exhibit metal chelating activity; however, it has shown that the gel formulation with 75% concentration on DPPH antioxidant assay and 50% concentration on ABTS free radical scavenging assay has antioxidant activity. Using One-Way ANOVA and Tukey HSD multiple comparisons, the researchers obtained a p-value of 1.000 and .08562 to compare the different concentrations and the positive control (vitamin E), indicating a significant difference. In conclusion, when formulated as a topical gel, the Banana (Musa sapientum) peel methanolic extract exerts an antioxidant activity.**

Keywords*— *Banana (Musa sapientum), methanolic extract, antioxidant, DPPH (1,1-diphenyl-2-picrylhydrazil) antioxidant assay, ABTS free radical scavenging assay, Metal chelating antioxidant assay

I. INTRODUCTION

The outermost skin layer, the stratum corneum, is a heterogeneous epidermis layer that is selectively permeable, shielding skin from drying and environmental effects while retaining sufficient water to ensure its role in hydrating skin. The degradation of skin function is primarily indicated by changes in the stratum corneum's integrity, which increase transepidermal water loss and decrease skin hydration (Hashim et al., 2023). As the skin primarily protects the body from harmful materials and radiation rays, there are certain substances that cause oxidative damage to the skin. Commonly known as "Reactive Oxygen Stress" (ROS), they are a subset of free radicals that contain oxygen which have the potential to bind to and destroy cell components, causing skin dryness, wrinkles, and premature aging (Rahmawati et al., 2018). Due to these known threats, the use of skin care cosmetics with an antioxidant activity that is thought to protect the skin cells from free radicals for medical and aesthetic purposes has been emphasized in recent years.

In modern medicine and cosmetic fields, antioxidants can be obtained from synthetic or natural ingredients. Although effective, synthetic antioxidants may contain chemicals that provide long-term adverse risks, such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) (Rahmawati et al., 2018). These chemicals are used freely and commonly in cosmetics. However, exposure to high doses may lead to kidney and liver intoxication (Chiang et al., 2021). Due to these long-term threats, alternative solutions for antioxidant compounds from natural ingredients that are not harmful to the skin are needed. One of these alternative sources of antioxidants is Phenolic, a substance found in plants. The substance has been proven to have a major and effective role in fighting against free radicals (Boo, 2019). Specifically, herbal extracts have shown great potential because of the complex composition of herbal sources.

Banana plants, which grow abundantly in Cagayan soil, have recently emerged as a potential source of phenolic antioxidants. Due to its nutritional value, bananas belong to the family Musaceae and are one of the most important tropical fruits in the world market. Apart from its nutritional value, previous research has also identified the plant as having high contents of phenolic, with banana peel samples yield ranging from 299.42 to 383.33 GAE/100 g samples and phenolic contents in ethanol extracts varying from 336.83 to 383.33 mg GAE/10 g of samples (Okolie, 2016). The researchers note these values to be significantly high and are of great potential when it comes to the production of antioxidants and more specifically, their utilization for cosmetic purposes.

In terms of its application as a product, gel and creams appear to be the most effective forms of the banana peel

samples. According to Thomas and Krishnakumar (2024), the gel form of banana peel is an easy-to-apply formula, which makes it a viable option for banana peel applications. In addition, the researchers noted that the forms must be tested for their physical properties and antioxidant activity. Dou et al. (2018) support this claim, as the researchers also endorsed free radical scavenging, metal chelating, and DPPH assay as effective tests for the antioxidant activity of substances. At the same time, male Wistar Rats appear to be the best medical research models for testing the antioxidant activities of substances, as research suggests that the physiology and genetic composition of the species are closely similar to humans (Achmad & Putri, 2021).

With the importance of skincare, the emerging popularity of antioxidant use in cosmetics, and the potential of banana peel as a source of phenolic antioxidants, this study aims to determine the antioxidant activity of Banana (*Musa sapientum*) peel methanolic extract formulated as a topical gel through metal chelating, ABTS free radical scavenging, and DPPH assay. It will further be subjected to physical property and bioassay testing. This study can be highly significant to skin care, alternative antioxidant sources, and plant research. More specifically, this study may be significant to the community in spreading awareness of the importance of skin care and the potential of banana peels for cosmetic applications. This study may also benefit medical researchers who aim to study in related fields by serving as a basis and an example for future research.

II. METHODS

Experimental design was used in this study. This experimental study included the exposure of different controls to metal chelating, ABTS free radical scavenging, DPPH antioxidant assays, physical property testing, and bioassay on wistar rats.

A. Subjects of the study

Wistar rat is a type of albino and outbred species from the genus Rodentia. This was used because it is particularly helpful in determining the antioxidant properties of materials (Abbasalipourkabir et al., 2015). Moreover, the model is the most common and is the standard accepted test subject for research due to its apparent similarity in physiology and genetic composition to humans (Achmad & Putri, 2021). This similarity allows researchers to test various activities of materials, as it is hypothesized to resemble the same effects in humans (Dasilva et al., 2021).

For this study, 5 male Wistar albino rats, aged 8-10 weeks and weighing 250-280 g, were utilized. The rats were obtained at the MOTS Animal House Laboratory and Research. Before starting the study, all rats had one week to get used to their housing condition. The rats were kept and housed in plastic cages in a temperature-controlled environment with a 12-hour light/dark cycle at 20 5 °C and 20%-30% humidity. They were fed laboratory rat food and tap water as needed before, during, and after therapy (Mohammad et al., 2022).

B. Collection and authentication of plant samples

The researchers collected the Banana (Musa sapientum) peel near the University of Saint Louis Tuguegarao, specifically in the school canteen and food stalls located inside and outside the school. These areas sell a variety of banana recipes, making them ideal places to gather samples. The botanical verification and authentication of the plant material was conducted at the Department of Agriculture's Bureau of Plant Industry, Carig Sur, Tuguegarao City, Cagayan.

C. Preparation of Plant Extract

The dried banana peel was cut into small pieces and powdered using a laboratory blender. The extraction method was followed by the extraction process used by Sugihartini et al. (2019). Extraction from 100 grams of powdered banana peel was carried out by solvent extraction method using 1000 mL 99% methanol solvent.

D. Preparation of Gel

The concentrations for the gel formulation; 25%, 50%, and 75% was determined to be the plant concentrations for this study as recommended by Vamanu et al (2012), where the aforementioned concentrations were stated as the standard for antioxidant and other plant activity testing. The preparation of the gel was accomplished using the method described by Sugihartini et al. (2019). The ingredients used for the preparation of the gel are as follows:

TABLE I. QUALITATIVE INTERPRETATION FOR MINIMUM INHIBITORY CONCENTRATIONS

Component	Uses	Formula 1	Formula 2	Formula 3
Banana (Musa sapientum) peel methanolic extract	Active ingredient	25%	50%	75%
CMC-Na	Thickening agent	0.3 grams	0.3 grams	0.3 grams
Glycerin	Humectant	2 grams	2 grams	2 grams
Propylene glycol	Humectant	1 ml	1 ml	1 ml
Methylparaben	Preservative	0.3 grams	0.3 grams	0.3 grams
Distilled water q.s.	Vehicle	-	-	-
		20 g	20 g	20 g

E. Determination of Antioxidant Activity

a) Metal Chelating Assay. The metal chelating activity was measured by adding 0.1 mM FeSO4 (0.2 mL) and 0.25 mM ferrozine (0.4 mL) subsequently into 0.2 mL of plant extract. After incubating at room temperature for 10 min, the absorbance of the mixture was recorded at 562 nm. The chelating activity was calculated using the following formula:

$$Metal\ chelating activity = \frac{Abs\ control - Abs\ sample}{Abs\ control}\ 100$$

Where Acontrol is the absorbance of control reaction (without plant extract), and Asample is the absorbance in the presence of a plant extract.

b) ABTS Free Radical Scavenging Assay. For ABTS assay, the stock solutions included 7 mM ABTS solution and 2.4 mM potassium persulfate solution. Set aside for 14 hours at

25 degrees Celsius for the reaction period. The solution was then diluted by mixing 1 ml ABTS solution with 60 ml methanol to obtain an absorbance of 0.706 ± 0.01 units at 734 nm using a spectrophotometer. Plant extracts (1 ml) were allowed to react with 1 ml of the ABTS solution, and the absorbance will be taken at 734 nm after 7 min using a spectrophotometer. The ABTS radical scavenging activity was calculated using the following formula:

$$\% = \frac{\text{Abs control} - \text{Abs sample}}{Abs\ control} * 100$$

Where Abs control is the absorbance of ABTS radical in methanol; Abs sample is the absorbance of ABTS radical solution mixed with sample extract/standard.

c) DPPH Assay. 2mg of DPPH powder was weighed and dissolved in 100 ml methanol. The solution was shaken and incubated in the dark for approximately 30 minutes at a temperature of 25 degrees Celsius. Once the period was complete, in a test tube containing 1 mL methanolic plant extract, add 2 mL of DPPH working solution. The absorbance read of the spectrophotometer would be set at 517 nm.

$$\%RSA = \frac{\text{Abs control} - \text{Abs sample}}{Abs\ control} * 100$$

F. Determination of Physicochemical Properties

Testing the physical properties of the gel was done using the same method described by Sugihartini et al. (2019). Five registered pharmacists, evaluated the different gel formulations through a Single-Blind Study wherein the chosen evaluators had no idea about the formulations they were evaluating. Direct observation of the gel's color and odor was used to conduct organoleptic testing. Using a 5-point Likert scale tool, the registered pharmacists evaluated the different physicochemical properties of the formulated gel.

Homogeneity, pH, spread power test, adhesion test and accelerated stability test were also conducted. Accelerated stability tests was done by keeping the gel sample in a carefully controlled laboratory setting and checked for any physical alterations after being subjected to temperatures as low as 10 °C, 20 °C, and as high as 40 °C to simulate room, cold, and hot temperatures on a routine basis for no more than 12 hours. Positive results were those with little to no changes in color, texture, or odor (Khenkin et al., 2019).

TABLE II. REFERENCE FINDINGS OF PHYSICOCHEMICAL PROPERTIES OF GEL FORMULATION

Paramater	Reference for Results
Color	Translucent
Odor	Pleasant Odor
Homogeneity	Homogeneous
pH	4.5-6.5
Spreadability	5-7 cm
Adhesion	Adhesive
Physical Stability	Stable

G. Test of Skin Irritation using Wistar Rats Model

For the direct testing of the Banana (*Musa sapientum*) peel gel formulations, including Negative control (Distilled water) and Hydorcholic Acid (Vitamin E) on Wistar Rats, the biocompatibility test was conducted (Pedrosa et al., 2016).

The rating scale was modeled after Luechtefeld et al. (2016) on the formulation and evaluation of gel for topical application. According to the study, compounds producing scores of less than 2 are considered negative or no skin irritation. The researchers used the criteria above to collect data, and the weighted mean was applied statistically. The irritation test of the gel was assessed using the Qualitative Interpretation of Five-Point Likert Scale Measurements, which is shown as follows:

TABLE III. QUALITATIVE INTERPRETATION OF IRRITATION TEST

Scale	Redness	Swelling
1	None	None
2	Slight	Slight
3	Well defined	Well defined
4	Moderate	Moderate
5	Scar Formation	Severe

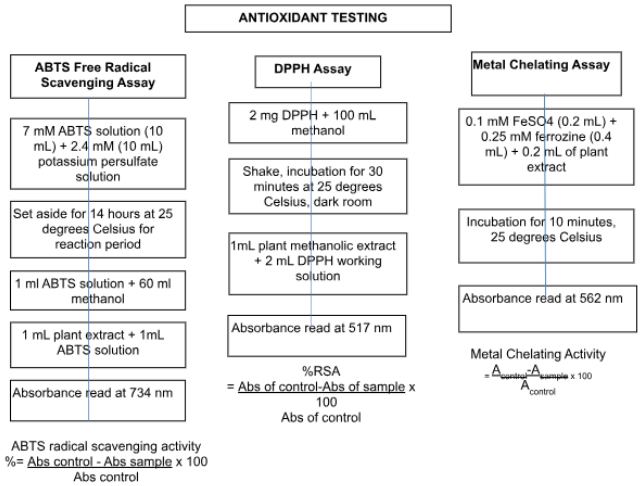

Fig. 1. Methodological Framework utilized in the study

H. Data Analysis

Mean was used to analyze the physicochemical properties and the irritation test. The mean of the evaluation of the physicochemical properties were interpreted as follows:

TABLE IV. QUALITATIVE INTERPRETATION OF EVALUATION FOR PHYSICOCHEMICAL PROPERTIES

Scale	Mean Range	Qualitative Interpretation
1	1.00-1.49	Not acceptable
2	1.50-2.49	Fairly Acceptable
3	2.50-3.49	Moderately Acceptable
4	3.50-4.49	Acceptable
5	4.50-5.00	Highly Acceptable

The result was also analyzed using an independent sample t-test and one-way analysis of variance (ANOVA) with Tukey's test for multiple comparisons. The significant value was set at $P > 0.01$.

I. Ethical Considerations

The researchers made sure that the standards set by the Bureau of Animal Industry (BAI) and Institutional Animal Care and Use Committee (IACUC) were followed and taken into consideration in handling the rats.

III. RESULTS AND DISCUSSION

The formulated Antioxidant Topical gel was a translucent-brown colored gel with a minty odor. It is an oil free moisturizer enriched with 100% natural origin Banana Peel extract used topically for smooth skin. The vicious texture of the gel makes it stay in place, and even after absorption the gel will remain cohesive. Its airless container preserves its natural properties, preventing the product from oxidizing through contact with air.

TABLE V. PHYSICAL PROPERTIES OF THE DIFFERENT CONCENTRATIONS OF BANANA (MUSA SAPIENTUM) PEEL METHANOLIC EXTRACT FORMULATED AS AN ANTIOXIDANT TOPICAL GEL

Pysicochemical Properties	**25% M. sapientum extract**	**50% M. sapientum extract**	**75% M. sapientum extract**
Color	Acceptable	Moderately Acceptable	Moderately Acceptable
Odor	Highly accepatble	Acceptable	Acceptable
Homogeneity	Highly accepatble	Highly accepatble	Acceptable
Stability	Highly accepatble	Acceptable	Acceptable
pH	5.54	5.68	5.40
Adhesion	1.12 ± 0.09 sec	1.64 ± 0.25 sec	1.06 ± 0.02 sec
Spreadability	7 cm	7 cm	7 cm

The physical properties of a 25% banana (*Musa sapientum*) peel methanolic extract formulated as an antioxidant topical gel were evaluated and assessed for color, odor, homogeneity, and stability. The results indicate that the color of the gel was rated between 4 and 5 on a scale of 1 to 5, with an average rating of 4.2. This suggests that the color of the gel is generally acceptable. The gel odor received consistently high ratings, with all evaluations ranging from 4 to 5 and an average rating of 4.6. This indicates that the odor of the gel is highly acceptable. The homogeneity of the gel was evaluated as 5 on a scale of 1 to 5 for all assessments, indicating a highly acceptable level of homogeneity. This suggests that the ingredients in the gel are well-mixed and evenly distributed, which is an important factor for a topical product to ensure consistent application and effectiveness. The stability of the gel was assessed and received a range of ratings from 4 to 5, with an average rating of 4.6. This indicates that the gel is highly stable, meaning it is capable of maintaining its physical properties and integrity over time. These results demonstrate that the 25% banana peel methanolic extract formulated as an antioxidant topical gel possesses favorable physical properties. The acceptable color and highly acceptable odor indicate that it is visually appealing and has an appealing scent, which can contribute to user satisfaction. The highly acceptable homogeneity suggests that the gel is uniform and consistent in texture, which facilitates easy and even application. Lastly, the gel's highly acceptable stability suggests that it can maintain its properties over time, which is crucial for maintaining its effectiveness and shelf life.

On the other hand, the color of 50% banana (Musa sapientum) peel methanolic extract formulated as a topical gel received ratings ranging from 2 to 4, with an average rating of 3. This suggests that the color of the gel is moderately acceptable. While some evaluations rated it higher, there were lower ratings as well, indicating that there may be room for improvement in the color aspect. The gel odor received consistently high ratings, with all evaluations ranging from 2 to 5 and an average rating of 4.2. This indicates that the odor of the gel is generally acceptable. However, there was a lower rating of 2, suggesting that there may be some variations in the perception of the odor. The homogeneity of the gel received highly acceptable ratings, with all evaluations scoring 5, except for one evaluation with a rating of 4. The average rating for homogeneity was 4.8, indicating a high level of uniformity and consistency in the gel's texture. The stability of the gel was assessed with ratings ranging from 3 to 5, with an average rating of 4.4. This suggests that the gel has acceptable stability, although there were some lower ratings indicating possible room for improvement in this aspect.

Furthermore, in terms of color of the 75% banana (Musa sapientum) peel methanolic extract formulated as an antioxidant topical gel, it scored an average of 3 on a scale ranging from 1 to 5, with 1 representing the lowest value and 5 being the highest. The overall average of 2.6 indicates that the color of the gel is moderately acceptable. While this score suggests that improvements could be made in terms of color, it is important to note that the acceptability of the gel is subjective, and slight variations in color may not significantly affect its performance. The odor of the gel received a higher average score of 3.6, which falls within the acceptable range. The score of 5 for three of the evaluations indicates that the odor is perceived as favorable, while scores of 1 and 2 for the remaining evaluations suggest room for improvement. Nonetheless, the overall acceptability of the odor suggests that the gel is suitable for topical application. Homogeneity, which refers to the uniform distribution of the gel's components, received an average score of 3.8, falling within the acceptable range. This indicates that the gel has a satisfactory level of homogeneity, with most evaluations scoring 4. However, one evaluation scored 3, suggesting the presence of slight variations in the distribution of components. Overall, the homogeneity of the gel is considered acceptable. The stability of the gel was assessed by evaluating its ability to maintain its properties over time. The gel received an average stability score of 4.4, indicating that it is stable and able to retain its characteristics adequately. The scores ranged from 4 to 5, suggesting that the gel demonstrates good stability over multiple evaluations. This finding is crucial, as stability is a crucial factor for a topical product's shelf life and effectiveness. The data analysis of the topical gel formulated using a 75% banana peel methanolic extract as an antioxidant reveals that the gel is moderately acceptable in terms of color, acceptable in terms of odor, and homogeneity, and shows good stability. These findings suggest

that the gel has the potential to be a viable product in the field of topical antioxidants. However, further studies and optimizations may be necessary to enhance its color and odor properties. This gel formulation's positive attributes align with previous research highlighting the potential antioxidant properties of banana peel extracts (Hashim et al., 2023; Teshome et al., 2023).

In addition, the pH is a crucial parameter in determining the acidity or alkalinity of a substance. The pH values were measured at different concentrations, namely 25%, 50%, and 75%. The pH values obtained ranged from 5.40 to 5.68. These results indicate that the product falls within a slightly acidic pH range, which is typically favorable for skin applications. It is important to note that the pH of topical products can significantly influence their compatibility with the skin, as the skin's natural pH falls within a slightly acidic range (Guo et al., 2023). Therefore, a product with a pH within this range is more likely to be well-tolerated by the skin.

Adhesion test was also conducted on the product at different concentrations. The adhesion test evaluates the ability of the product to adhere to the skin. The measurements were recorded in replicates, and the average values along with the standard deviations, are provided for each concentration. At a concentration of 25%, the adhesion values obtained in replicates I, II, and III were 1.22, 1.05, and 1.09, respectively. The average adhesion value was calculated to be 1.12 ± 0.09. Similarly, at a concentration of 50%, the adhesion values were 1.90, 1.60, and 1.41, resulting in an average adhesion value of 1.64 ± 0.25. Lastly, at a concentration of 75%, the adhesion values were consistently low, with replicates I, II, and III recording 1.09, 1.05, and 1.05, respectively, leading to an average adhesion value of 1.06 ± 0.02. The data indicate that as the concentration of the product increases, the adhesion values generally increase as well. This suggests that a higher concentration of the product may enhance its adhesion properties. However, it is important to note that the standard deviations for the average adhesion values vary, indicating some variability in the adhesion performance at different concentrations. It is worth considering that factors such as formulation composition, viscosity, and skin interactions can influence a topical product's adhesion properties (Xu et al., 2021). However, the adhesion test results suggest that the product exhibits concentration-dependent adhesion characteristics, with higher concentrations generally associated with increased adhesion.

And lastly for the physical property testing, the spreadability refers to the ease with which a product can be spread or applied onto the skin. The spreadability measurements were consistently recorded at 7 cm, indicating that the product has a uniform and satisfactory spreadability. This means that the formulation is easy to spread onto the skin, which is desirable for topical products as it facilitates even application and absorption. However, it is important to consider that other factors, such as viscosity and texture, can also impact the spreadability of a product (Gaur et al., 2014).

TABLE VI. PHYSICAL PROPERTIES OF THE DIFFERENT CONCENTRATIONS OF BANANA (MUSA SAPIENTUM) PEEL METHANOLIC EXTRACT FORMULATED AS AN ANTIOXIDANT TOPICAL GEL

Pysicochemical Properties	DPPH		ABTS		Metal Chelating	
	Mean	QI	Mean	QI	Mean	QI
25% M. sapientum extract	24.58 ±1.48	Mild	13.89 ±1.85	Mild	-368.75 ± 0	None
50% M. sapientum extract	29.03 ±2.88	Moderate	43.24 ±0.31	Potent	-368.75 ± 0	None
75% M. sapientum extract	49.83 ±4.92	Potent	18.07 ±1.06	Moderate	-368.75 ± 0	None
Postive control (Vitamin E)	96.08 ±0.67	Potent	96.11 ±0.67	Potent	70.31 ± 0.22	None
Negative control (Distilled water)	-21.95 ± 0	None	-0.43	None	86.15 ± 0.94	None

The absorbance activity of banana peel extract formulated as an antioxidant topical gel was also assessed through the DPPH assay. The experimental group consisted of different concentrations (25%, 50%, and 75%) of the gel, while the control group exhibited a constant absorbance value of 0.697, indicating no inherent antioxidant activity. The percentage inhibition values reflect the ability of the banana peel extract formulations to scavenge DPPH radicals, serving as an indicator of their antioxidant potential. The average percentage inhibition for the 25% concentration was calculated as 24.58 ± 1.48%, suggesting a moderate inhibitory effect on the DPPH radicals. This finding indicates that the 25% formulation possesses some level of antioxidant activity, albeit at a relatively lower potency. Whereas, the 50% concentration demonstrated a higher average percentage inhibition of 29.03 ± 2.88%, indicating a stronger inhibitory effect on the DPPH radicals compared to the 25% formulation. These results suggest a higher antioxidant activity for the 50% formulation, likely due to the increased concentration of the banana peel extract. The highest inhibitory effect on the DPPH radicals was observed in the 75% concentration, exhibiting an average percentage inhibition of 49.83 ± 4.92%. This finding suggests a potent antioxidant activity of the 75% formulation, surpassing the effects of both the 25% and 50% concentrations. Additionally, the absorbance activity of Vitamin E, serving as the positive control in the study was also assessed. The control group's absorbance remained constant at 0.697, while the samples containing Vitamin E exhibited lower absorbance values. The percentage inhibition values demonstrate the ability of Vitamin E to scavenge the DPPH radicals, indicating its antioxidant activity. The average percentage inhibition, calculated from the three replicates, was determined to be 96.08 ± 0.67%. These results suggest that Vitamin E has a potent inhibitory effect on the DPPH radicals, with an average inhibition of approximately 96%. Vitamin E is widely recognized as a powerful antioxidant because it neutralizes free radicals and protects against oxidative damage (Rizvi, 2014). It is commonly used as a positive control in antioxidant studies to evaluate the efficacy of other antioxidant compounds. The high percentage inhibition observed in this study aligns with previous research highlighting the strong antioxidant activity of Vitamin E. It reinforces its effectiveness in scavenging free radicals and further validates its position as a well-established antioxidant compound. And for the absorbance activity of distilled water, serving as the negative control in the study exhibited higher absorbance values, while the control group's

absorbance remained constant at 0.697. The percentage inhibition values indicate the ability of the samples to scavenge the DPPH radicals. Surprisingly, the negative control of distilled water showed negative percentage inhibition values of approximately -21.95%. This suggests that distilled water did not exhibit any inhibitory effect on the DPPH radicals. Negative values in percentage inhibition are uncommon in antioxidant studies and indicate that the sample may not possess antioxidant activity or might even contribute in generating free radicals. Distilled water is often used as a negative control in antioxidant assays to evaluate the test system's baseline activity and account for any non-specific effects (Leopoldini et al., 2012). Its lack of antioxidant properties is well-known, as water itself does not possess the ability to scavenge free radicals or exhibit significant antioxidant activity. The negative percentage inhibition observed in this study further confirms the expected outcome for distilled water as a negative control, indicating that it does not contribute to the inhibition of DPPH radicals. It emphasizes the importance of using appropriate controls to differentiate between the test samples' effects and the solvent or vehicle's inherent antioxidant activity.

The absorbance activity of banana peel extract formulated as an antioxidant topical gel was assessed through the ABTS assay as well. The experimental group included different concentrations (25%, 50%, and 75%) of the gel formulation, while the control group exhibited a constant absorbance value of 0.703. The percentage inhibition values represent the ability of the banana peel extract formulations to inhibit the ABTS radicals and indicate their antioxidant activity. The average percentage inhibition was calculated from the three replicates. For the 25% concentration, the average percentage inhibition was determined to be 13.89 ± 1.85%. These results suggest a modest inhibitory effect on the ABTS radicals for the 25% formulation. The 50% concentration showed a higher average percentage inhibition of 43.24 ± 0.31%. This indicates a stronger inhibitory effect on the ABTS radicals compared to the 25% concentration, suggesting a higher antioxidant activity for the 50% formulation. The average percentage inhibition for the 75% concentration was 18.07 ± 1.06%. This concentration demonstrated a moderate inhibitory effect on the ABTS radicals, albeit lower compared to the 50% formulation. The ABTS assay is commonly used to assess the antioxidant capacity of samples by measuring their ability to scavenge ABTS radicals (Ilyasov, 2020). The percentage inhibition values obtained from this assay provide insights into the antioxidant potential of the banana peel extract formulations. Further to that, the absorbance activity of Vitamin E, serving as the positive control in the study was assessed as well. The control group's absorbance remained constant at 0.703, while the samples containing Vitamin E exhibited significantly lower absorbance values. The percentage inhibition values demonstrate the ability of Vitamin E to scavenge the ABTS radicals, indicating its strong antioxidant activity. The average percentage inhibition, calculated from the three replicates, was determined to be 96.11 ± 0.67%. These results indicate that Vitamin E has a potent inhibitory effect on the ABTS radicals, with an average inhibition of approximately 96%. Vitamin E is well-known for its excellent antioxidant properties, as it acts as a free radical scavenger and protects against oxidative stress (Rizvi, 2014). It is often used as a positive control in antioxidant studies to evaluate the effectiveness of other antioxidant compounds. The high percentage inhibition observed in this study aligns with the established knowledge of Vitamin E's robust antioxidant activity. It reinforces the efficacy of Vitamin E in scavenging ABTS radicals and validates its role as a positive control in antioxidant assays. And for the absorbance activity of distilled water, serving as the negative control in the study exhibited slightly lower absorbance values while the control group's absorbance remained constant at 0.703. The percentage inhibition values indicate the ability of the samples to inhibit the absorbance, reflecting their antioxidant activity. Surprisingly, the negative control of distilled water showed negative percentage inhibition values of approximately -0.43%. This suggests that distilled water did not exhibit any inhibitory effect on the absorbance or show no antioxidant activity. Distilled water is commonly used as a negative control in antioxidant assays to assess the baseline activity of the test system and account for any non-specific effects (Leopoldini et al., 2012). Its lack of antioxidant properties is well-established, as water itself does not possess the ability to scavenge free radicals or exhibit significant antioxidant activity. The negative percentage inhibition observed in this study further confirms the expected outcome for distilled water as a negative control, indicating that it does not contribute to the inhibition of absorbance or possess any antioxidant activity. This highlights the importance of appropriate controls to differentiate between the test samples' effects and the solvent or vehicle's inherent antioxidant activity.

And for the Metal Chelating Assay, this assay measures the ability of the sample to chelate or bind with metal ions, indicating its potential metal-chelating activity and ability to inhibit metal-induced oxidation. Surprisingly, the experimental group containing different concentrations (25%, 50%, and 75%) of the gel formulation showed negative percentage inhibition values of -368.75%. This suggests that the banana peel extract formulated as an antioxidant topical gel did not exhibit metal chelating activity or the ability to inhibit metal-induced oxidation in this particular assay. Metal chelating activity is an important property of antioxidants as it can help in reducing metal-catalyzed oxidative damage (Raza et al., 2019). However, the results obtained in this study do not support the presence of significant metal chelating activity in the banana peel extract gel formulation. The vitamin E, serving as the positive control in the metal chelating assay exhibited significantly lower absorbance values while the control group's absorbance remained constant at 0.64. The percentage inhibition values indicate the ability of Vitamin E to inhibit the absorbance, reflecting its metal chelating activity. The average percentage inhibition, calculated from the three replicates, was determined to be 70.31 ± 0.22%. These results indicate that Vitamin E has a notable inhibitory effect on the absorbance and demonstrates significant metal chelating activity in this assay. Vitamin E is well-known for its antioxidant properties, including its ability to chelate metal ions (Rizvi, 2014). It acts as a metal chelator, preventing metal-induced oxidative damage by binding to metal ions and inhibiting their reactivity. The high percentage inhibition observed in this study aligns with the established knowledge of Vitamin E's metal-chelating activity. It reinforces the efficacy of Vitamin E in chelating metal ions and validates its role as a positive control in metal chelating

assays. And the distilled water, serving as the negative control in the metal chelating assay exhibited slightly lower absorbance values while the control group's absorbance remained constant at 0.64. The percentage inhibition values indicate the ability of the samples to inhibit the absorbance, reflecting their potential metal-chelating activity. The average percentage inhibition, calculated from the three replicates, was determined to be 86.15 ± 0.94%. These results suggest that distilled water shows a significant inhibitory effect on the absorbance in this assay. Distilled water is commonly used as a negative control in metal chelating assays to assess the baseline activity of the test system and account for any non-specific effects (Mekmouche et al., 2017). The negative percentage inhibition values observed in this study for distilled water indicate its ability to inhibit the absorbance, possibly due to non-specific interactions with the assay components or background effects.

Finally, bioassay test was conducted on different groups using an experimental product at varying concentrations (25%, 50%, and 75%), a negative control group (distilled water), and a positive control group (Vitamin E). The bioassay test evaluated the effects of the product on swelling and redness in rats at different time intervals (1 hour, 24 hours, 48 hours, and 72 hours). Across all experimental groups (25%, 50%, and 75%), no significant swelling or redness was observed in any of the rats after 1 hour, 24 hours, 48 hours, or 72 hours. The absence of these adverse effects indicates that the experimental product did not cause any visible irritation or inflammation on the rats' skin. Comparatively, the negative control group, which was exposed to distilled water, also exhibited no swelling or redness in any of the rats throughout the testing period. This suggests that the distilled water used as the control did not induce any skin irritation or inflammatory response. The positive control group, treated with Vitamin E, also displayed no signs of swelling or redness in any of the rats at all-time intervals. This outcome aligns with the expected results, as Vitamin E is known for its anti-inflammatory properties and is commonly used as a reference substance in skin irritation tests (Mohamed et al., 2020).

This study has limitation which was the lack of related studies of formulated product that undergone antioxidant test. Usually, it is the extract that is subjected to antioxidant testing.

IV. Conclusion

In conclusion, using the United States Pharmacopeia (USP) Organoleptic Parameter, the 25%, 50%, and 75% banana (Musa sapientum) peel methanolic extract formulated as an antioxidant topical gel passed the set standards. The three gel formulations were translucent, had a pleasant odor, homogenous, and highly stable. Furthermore, the pH values obtained ranged from 5.40 to 5.68, which is typically favorable for skin applications. The spreadability measurements were consistently recorded at 7 cm, indicating that the product has uniform and satisfactory spreadability. Moreover, when it comes to adhesion, as the concentration of the products increases, the adhesion values generally increase as well. This only means that a higher product concentration may enhance its adhesion properties. Other than that, based on the bioassay test results, it can be concluded that the experimental product, even at different concentrations (25%, 50%, and 75%), did not cause any observable adverse effects, such as swelling or redness, on the rats' skin. These findings suggest that the product may have a low potential for skin irritation. Finally, based on all the data gathered and analyzed including the antioxidant tests, the researchers conclude that the Banana (Musa sapientum) peel methanolic extract, when formulated as a topical gel, exerts an antioxidant activity making the research gap filled. This was proven by the data collected and justified by the statistical analysis of this research.

V. Recommendations

In view of the results of the study, the researchers recommend further testing of the developed product to determine its viability and potential for manufacturing. Studies should be done to include testing for shelf-life, long term stability and similar studies. The researchers recommend collaboration with DOST and PITAHC for further development and improvement of the product.

II. Acknowledgement

The researchers want to give their most profound appreciation to the accompanying people for their unending help that made this study possible. The researchers also extends their gratitude to the School of Allied Health Sciences and the University of Saint Louis. Finally, to the Almighty Father for giving them the strength, assurance, and capacity to complete this investigation.

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