JPPIPA 11(7) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effect of Moringa Oleifera Extract on Melatonin Levels and Skin Cell Images in Rattus Novergicus Exposed to Ultraviolet Rays

Irma Rosalina[1*], Harliansyah[2], Ira Kusumawaty[3]

[1] Department of Master of Biomedical Sciences, Graduate School, YARSI University, Jakarta, Central Jakarta, Indonesia.
[2] Department of Master of Biomedical Sciences, Graduate School, YARSI University and Center for Telomere, Longevity and Oxidative Stress Research (PUSLIT TELOS) YARSI University, Jakarta, Central Jakarta, Indonesia.
[3] Department of Nursing, Poltekkes Kemenkes Palembang, Palembang, South Sumatera, Indonesia.

Received: May 08, 2025
Revised: June 16, 2025
Accepted: July 25, 2025
Published: July 31, 2025

Corresponding Author:
Irma Rosalina
irmarosalinabiomedik@gmail.com

DOI: 10.29303/jppipa.v11i7.11298

Abstract: Exposure to ultraviolet (UV) light has negative effects on skin health, including decreased melatonin levels and increased skin cell damage. This study investigated the effects of Moringa oleifera (MO) leaf extract on melatonin levels and skin damage induced by UVB light in male Sprague Dawley rats. Utilizing a post-randomized controlled group design, 28 rats were allocated into four groups: a control group without treatment and a treatment group subjected to UVB exposure alongside MO extract at doses of 300 mg/kg and 600 mg/kg. Melatonin levels were quantitatively assessed via spectrophotometry, while histopathological analysis was employed to evaluate skin damage. Results indicated that rats receiving the 600 mg/kg MO extract exhibited the highest melatonin levels, contrasting sharply with the group exposed solely to UVB radiation, which showed significantly reduced melatonin. Histological examination revealed a marked decrease in sunburn cell lesions in the MO extract-treated group compared to the control group lacking treatment. In conclusion, Moringa oleifera leaf extract appears to enhance melatonin production and mitigate UV-induced skin damage, suggesting its potential as a protective agent in dermatological practices. These findings warrant further exploration into the application of MO extract in developing preventive therapies against UV-related skin damage.

Keywords: Melatonin; Moringa oleifera; Norvegicus rats; Skin cells; Ultraviolet bETA (UVB) rays

Introduction

Moringa oleifera, often hailed for its rich nutritional profile and therapeutic potentials, has drawn significant interest in dermatological research, particularly concerning its antioxidant properties. The leaves of Moringa oleifera are abundant in bioactive compounds such as flavonoids, phenolic acids, and glucosinolates, which confer substantial antioxidant activity. These antioxidants are instrumental in counteracting oxidative stress induced by ultraviolet (UV) exposure, particularly UVB rays known to cause skin damage and sunburn (Abd-Elnaby et al., 2022; Chengama Raju et al., 2023).

Furthermore, Moringa oleifera contains specific antioxidants like quercetin and chlorogenic acid that enhance skin health by potentially modulating melatonin levels, a hormone known for its protective effects against oxidative stress (Abd-Elnaby et al., 2022). The synergistic action of these bioactive compounds underlines Moringa's capability in promoting skin resilience against environmental stressors (Fatiqin et al., 2021). Therefore, Moringa oleifera emerges not only as a

How to Cite:
Rosalina, I., Harliansyah, & Kusumawaty, I. (2025). The Effect of Moringa Oleifera Extract on Melatonin Levels and Skin Cell Images in Rattus Novergicus Exposed to Ultraviolet Rays. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 348–358. https://doi.org/10.29303/jppipa.v11i7.11298

nutritional supplement but also as a promising therapeutic agent for enhancing skin health.

Studies have shown that melatonin not only plays a role in plant stress responses but also exhibits anti-inflammatory and antioxidant properties that may influence mammalian responses to UV radiation (García-García et al., 2020; Tiwari et al., 2021). Melatonin has been extensively studied for its roles in plant stress mitigation and its protective effects against oxidative stress in mammals, particularly in response to ultraviolet (UV) radiation. Research indicates that melatonin enhances antioxidant defense mechanisms by scavenging free radicals and modulating oxidative stress responses. For example, it has been shown to have protective effects in Sprague-Dawley rats, which serve as a common model in these studies (Farid et al., 2021). Specifically, melatonin supplementation has demonstrated protective effects against UV-induced skin damage, suggesting that it could potentially improve skin health and resilience after UV exposure (Xie et al., 2022).

The impact of excessive UV exposure on mammalian skin, particularly the skin of Sprague Dawley rat, is of major concern. UVB radiation is known to induce the formation of sunburn cells, characterized by apoptotic cell death in the epidermis. This is important because it can cause long-term skin damage and increase the risk of skin cancer. Antioxidant compounds derived from plant sources, such as Moringa oleifera, may offer a protective mechanism against cell damage. Studies have shown that various plant extracts can reduce TNF-α levels and increase cell survival by counteracting UV-induced damage (Dewi et al., 2024; Lailiyah et al., 2017).

Furthermore, the potential of Moringa oleifera leaf extract as a natural supplement to regulate melatonin levels presents an opportunity to be explored. Evidence of melatonin's role in improving skin integrity and resistance to UV radiation underscores the need for functional foods that can provide dermatological benefits (Padumanonda & Johns, 2013). Moringa oleifera may contribute to increasing endogenous melatonin levels while providing antioxidative protection against oxidative stress associated with ultraviolet (UV) exposure. Moringa leaves are rich in flavonoids, particularly quercetin, recognized for their antioxidant properties, which can bind to free radicals, thus reducing oxidative stress effectively (Meena et al., 2020). Furthermore, while there is evidence that melatonin plays a regulatory role in plant physiology, proving the direct presence of melatonin in Moringa and its effect on endogenous levels requires further investigation (Ma et al., 2017; Shi et al., 2024).

The novelty of this research lies in investigating the synergistic interaction between Moringa oleifera leaf extract and endogenous melatonin levels in Sprague Dawley rats, particularly focusing on their combined efficacy in protecting against UVB-induced cellular damage. This study is significant for several reasons such as it addresses the pressing need for natural alternatives to synthetic agents in skin health, tapping into the multifunctional capacities of Moringa oleifera. This research also enhancing our understanding of melatonin's role in skin integrity amid environmental stressors may pave the way for innovative therapeutic strategies against skin disorders and malignancies associated with UV exposure, making a meaningful contribution to both dermatological and broader health research.

This study aims to analyze the effects of Moringa oleifera leaf extract on melatonin levels and UVB-induced skin damage in Sprague Dawley rat. By combining biochemical assays and imaging techniques, such as histological examination of epidermal tissue, this study will confirm the efficacy of the plant extract in preventing sunburn and delineate the underlying mechanisms of cell protection associated with increased melatonin levels. The relevance of melatonin in dermatology, together with the multifunctional attributes of Moringa, highlight the importance of this study in contributing to the body of knowledge regarding natural interventions for skin health.

Method

Design

This research is an experimental laboratory with a randomized post-test control group design using male Spraque dawley experimental animals as research objects.

Location

Malonaldehyde and melatonin examination in the Integrated Research Laboratory of Yarsi University and histology examination in the V-Stem INOVASI PRIMA laboratory. The implementation of sampling and research work was carried out in January - April 2025.

Population

Population of Spraque dawley rats obtained from the V-Stem INOVASI PRIMA laboratory.

Sample Inclusion and Exclusion Criteria

This study used an animal model in the form of Sprague Dawley rats with strict inclusion and exclusion criteria to ensure the validity and resolution of the results. Inclusion criteria included the use of pure male rats from the Sprague Dawley strain, aged two months, with a body weight ranging from 130-160 grams. In addition, the rats used must be free from anatomical

abnormalities, in good health, and show good motor activity. All subjects must survive during the study period. Conversely, exclusion criteria eliminated rats that showed signs of illness during the adaptation period, died during experimental treatment, and had visible physical abnormalities. By adhering to these criteria, the study is expected to produce accurate and accountable data in a scientific context.

Sample Group

In this study, the samples used were white Sprague Dawley rats divided into four treatment groups. Group K consisted of rats that received no treatment or is called the negative control, while group P1 received Beta UV light treatment without Moringa oleifera leaf extract or is called the positive control. Groups P2 and P3 each received Moringa leaf extract at doses of 300 mg/kg and 600 mg/kg, respectively, along with Beta UV light.

The sample size calculation refers to WHO standards using the Federer formula. With t = 4, the formula produces a minimum sample size requirement of 6 rats per group. To anticipate a potential dropout of 10%, further calculations show that each group requires around 7 rats, so that the total sample for this study is 28 rats divided equally into the four groups. This methodology ensures the representativeness and validity of the data obtained in the study.

Tools and Materials

In this experiment, various tools, materials, and experimental animals have been used to achieve the research objectives. Research Tools: The main instruments consist of a laptop, printer, Betha ultraviolet lamp brand Philips PL-S 9w/01/2P, spectrophotometer, Elisa reader, and electron microscope. Additional supporting tools include rat cages, Betha ultraviolet copying boxes, digital scales, syringes, knives, probes, microtubes, cameras, and blenders. Research Materials: The main material used in this study is moringa leaves. Kit Rat Melatonin Elebsience, Thiobarbituric Acid (TBA) 0.5%, and Trichloroacetic Acid (TCA) 20% are also important components. The experimental animals used were male Sprague Dawley white rats, 2 months old with an average weight of 130-160 g. Rat skin tissue and a standard ration containing 20-21% protein, 4-5% fat, 6% fiber, and 8% ash were also provided, with drinking water provided ad libitum.

Making Moringa Leaf Extract

Moringa leaf simplicia maceration was carried out based on the method of Andriani et al. (2018). Moringa leaf extract was made by macerating 1000 grams (1 kg) of dried moringa leaves, crushed using a blender, added with 96% ethanol solvent, put into a container, closed and left for two days protected from sunlight. This mixture was filtered to obtain macerate. The dregs were macerated with 96% ethanol using the same procedure. Maceration was carried out until a clear macerate was obtained. The macerate was evaporated using a vacuum rotary evaporator at a temperature of 40 0C.

The dosage of Moringa leaves depends on the weight of the rat. In this study, the dosage given was 1ml, with the following calculation principle: The average body weight of the white Spraque Dawley rats used in this study was 150 g.

The dosage of Moringa leaves in the experiment was based on the principle of maximizing physiological effects based on the body weight of the subject, in this case, white Sprague-Dawley rats. For accurate administration, the volume of the extract must indeed be varied to ensure that the specific dose (300 mg/kgBW or 600 mg/kgBW) is achieved according to the body weight of each rat. So, if the average weight of a rat is 150 g (0.15 kg), the individual dose must take this weight into account. The 1 ml claim needs to be checked: at a dose of 300 mg/kgBW, a rat weighing 150 g would receive 45 mg (for a total volume of 0.15 ml). Similarly, for a dose of 600 mg/kgBW, the volume required is 0.3 ml.

Table 1. Calculation of Moringa Leaves

Type	Dose	Calculation
Moringa Leaves	300mg/kgBW	300 mg/kg body weight x 0.15 kg rat body weight = 45 mg/1 ml
Moringa Leaves	600mg/kgBW	600 mg/kgbb x 0.15 rat bb = 90 mg/1 ml

Animal Treatment

This study involved 28 rats that were acclimated to the laboratory environment for one week to minimize stress and standardize their lifestyle. The rats were kept in 20x25x50 cm cages, with their health monitored daily. Weighing was done weekly using a digital scale. The hair removal process was carried out on the back using a hair removal cream before exposure to UVB light for 5 times a week, followed by a rest period before intraperitoneal treatment. The rats were divided into four groups: a control group and three groups with UVB exposure treatment with or without moringa leaf extract. Necropsy was performed after completion of the experiment, where skin tissue and blood samples were taken for further analysis. The euthanasia protocol used ketamine and xylazine. The method of serum collection by centrifugation is described in detail to ensure quality until.

The timing of necropsy and sampling after the last UVB exposure and extract administration is critical to understanding the physiological effects induced by the treatment. In a common protocol, necropsy is performed 24 to 72 hours post-treatment to allow sufficient biological responses to manifest, facilitating the assessment of potential pathological changes and biochemical markers in tissue and serum.

The rats underwent a hair removal process followed by UVB exposure for five days a week, suggesting that the UVB treatment was scheduled prior to the administration of the Moringa extract, labeled as "intraperitoneal treatment." Moringa leaf extract was administered after the UVB exposure, particularly due to the "rest period" mentioned before treatment. Intraperitoneal injection allows for direct delivery into the bloodstream, which could enhance the immediate effectiveness of the treatment in mitigating any potential effects caused by UVB exposure. Such considerations are critical for ensuring the reliability of the study's outcomes and their applicability to broader contexts.

Ultra Violet Beta Ray Exposure

The present study meticulously investigated the effects of Ultraviolet B (UVB) light on biological responses, administering a cumulative total dose of 100 Minimal Erythemal Dose (MED) or 6 J/cm² across eight weeks, with a regimen of five exposures per week. The dosage was escalated following a structured schedule: Weeks 1-2 received 1 MED (60 mJ/cm², 566 seconds), Weeks 3-4 2 MED (120 mJ/cm², 1132 seconds), Weeks 5-6 3 MED (180 mJ/cm², 1698 seconds), and Weeks 7-8 4 MED (240 mJ/cm², 2264 seconds). The exposure was consistently monitored, sustaining an average intensity of 106 µW/cm², thereby confirming the linear correlation between exposure duration and energy absorption. This meticulous control of UVB exposure parameters is crucial for elucidating the biological responses elicited by varying UVB doses.

Research Ethics

This research has passed the ethical test from the Research Ethics Committee of the Yarsi University Research Institute with Number 184/Kep-Uy/Bia/Vi/2025.

Data Analysis

Before conducting this analysis, the Shapiro-Wilk normality test showed that the data were normally distributed ($p>0.05$). Furthermore, the analysis was carried out through the One Way ANOVA test followed by the Bonferroni Post Hoc test to identify variations between groups. The significance criteria were determined with a p value <0.05. The data were presented in the form of tables and graphs.

Research Flow Chart

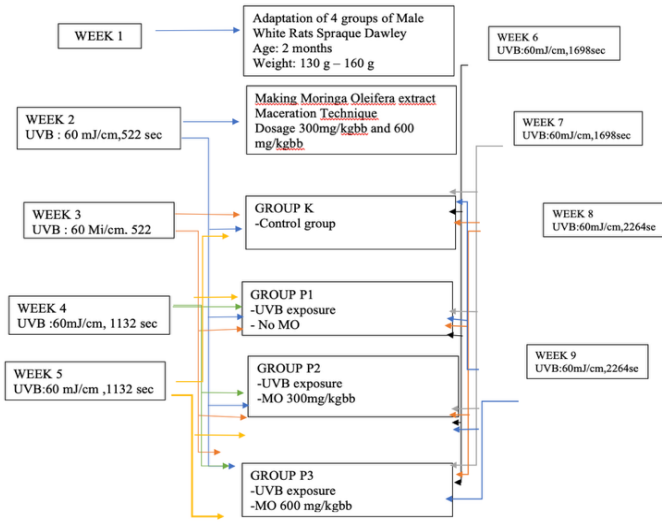


Figure 1. Flow chart

Result and Discussion

Table 2 presents the average melatonin levels in four groups of mice with different treatments, along with indicators of data normality. The highest melatonin levels were found in the group of mice receiving UVB treatment and 600 mg/kg moringa leaf extract (231.99357), followed by the group with 300 mg/kg extract (211.76786). The group exposed to UVB alone showed melatonin levels of 201.76500, while the group without treatment had the lowest average level (196.47643).

Table 2. Average Values of Melatonin Levels in 4 Groups of Mice

Group of Rats	Average Melatonin Levels	Normality data
Without Treatment	196.47643 years	0.170
UVB rays	201.76500	0.013
UVB+Moringa leaf extract 300 mg/kg	211.76786 years	0.796
UVB+Moringa leaf extract 600 mg/kg	231.99357	0.950

The normality assessment of the data showed that the untreated group (0.170) and the group with 300 mg/kg moringa leaf extract (0.796) met the normality assumption, while the group treated with UVB (0.013)

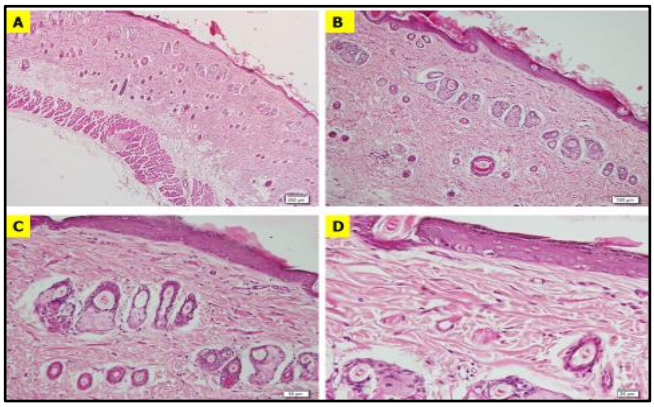
did not meet the assumption. Similarly, the group with 600 mg/kg moringa leaf extract showed good normality (0.950). These findings indicate the potential positive effect of moringa leaf extract on melatonin levels, especially in the context of UVB exposure.

The results of the homogeneity test of the treatment groups using the Levene test produced a p value of 0.627 ($p > 0.05$) which indicates that the melatonin levels in the treatment groups have the same variance.

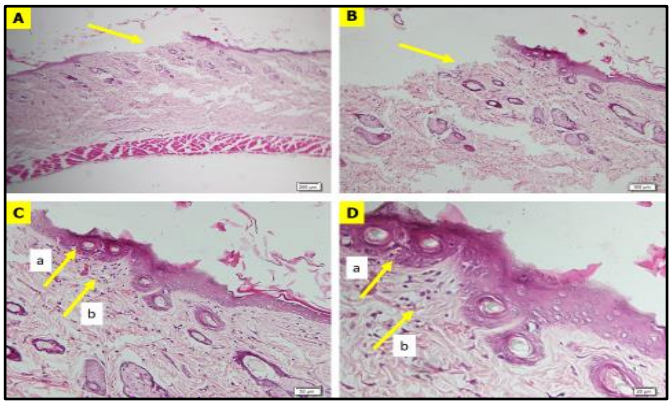
Table 3. Bonferroni Post Hoc Significance Values Per Group

	Without treatment (Sig.)	UVB (Signature)	UVB+Moringa leaf extract 300 mg/kg (Sig.)	UVB+Moringa leaf extract 600 mg/kg (Sig.)
Without treatment		1,000	0.102	0.000
UVB rays	1,000		0.637	0.000
UVB+Moringa leaf extract 300 mg/kg	0.102	0.637		0.014
UVB+Moringa leaf extract 600 mg/kg	0.000	0.000	0.014	

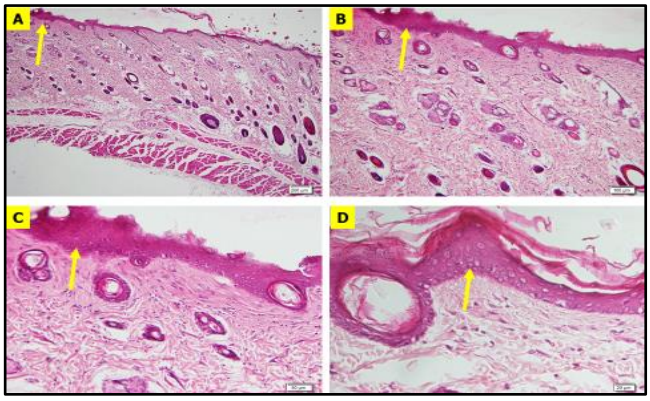
Table 3 presents the significance value of the Bonferroni Post Hoc test results between treatment groups in an experimental study. The comparison between the "UVB" and "UVB + Moringa leaf extract 600 mg / kg" groups with a value of 0.000 implies that there is a very significant difference. Likewise, a value of 0.014 indicates significance between the "UVB + Moringa leaf extract 300 mg / kg" and "UVB + Moringa leaf extract 600 mg / kg" groups. Overall, these data indicate that the moringa leaf extract treatment contributes to reducing the negative effects of UVB exposure, especially at higher doses.



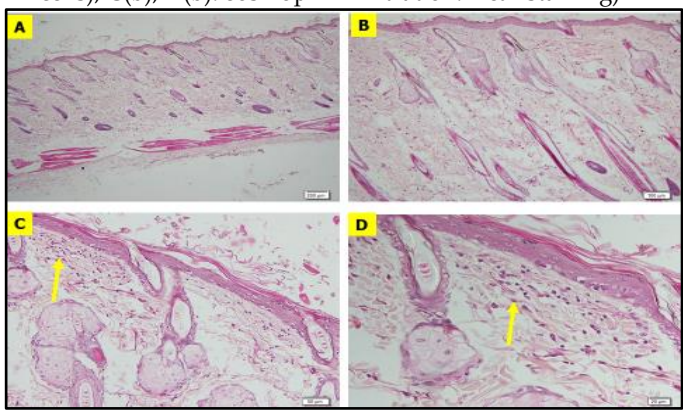
Control Group (No specific abnormalities (TKS) histologically)



Group P1 (Skin in A and B: some of the stratum corneum and epidermis are lost due to experiencing erosion (desquamation) and edema, C (a), D (a): hyperkeratosis, thickened epidermis, accompanied by keratinocytes with apoptotic nuclei (sunburn cells), C(b), D(b): eosinophil infiltration. H&E staining)



Group P2 (Skin in A, B, C, D: hyperkeratosis, thickened epidermis, accompanied by keratinocytes with intiapoptosis (sunburn cells). H&E staining)



Group P3 (Skin in A, B, no specific abnormalities (TKS), stratum corneum, epidermis, dermis and hypodermis normal, C and D: eosinophil infiltration in the dermis. H&E staining)

Figure 2. Image of sunburn cells in male spraque dawley rats exposed to betha ultraviolet light (Information: a. 4x magnification, b. 10x magnification, c. 20x magnification, d. 40x)

Figure 2 shows that the control group did not show any specific abnormalities (TKS). In contrast, the UVB-exposed group (P1) showed moderate to severe lesions, with significant damage to the stratum corneum and epidermis. In the groups treated with Moringa Oleifera extract (P2 and P3), there was a decrease in the severity of the lesions, and in group P3, no specific abnormalities were found, indicating the protective potential of Moringa Oleifera extract. Thus, Moringa Oleifera extract has a significant impact on reducing the effects of skin damage caused by UVB exposure in mice.

Based on table 4, it was obtained that the administration of moringa leaf extract can reduce the level of lesions in male mice exposed to UVB rays. Administration of 600 mg/kg moringa leaf extract had the highest number in reducing lesions in mice with no lesions as many as 3 or 42.95, mild degree 3 (42.9%) and moderate lesion 1 (14.3%).

Table 4. Frequency Distribution of Lesion Degree in SD Rats

Degree of Lesion	Without Treatment		UVB rays		Group UVB+Moringa leaf extract 300 mg/kg		Group UVB+Moringa leaf extract 600 mg/kg	
	F	%	F	%	F	%	F	%
There are no physical abnormalities	7	100	0	0	1	14.3	3	42.9
Light	0	0	0	0	5	71.4	3	42.9
Currently	0	0	4	57.1	1	14.3	1	14.3
Critical	0	0	3	42.9	0	0	0	0
Amount	7	100	7	100	7	100	7	100

Based on table 5, it is obtained that the highest average can be seen from the UVB group and decreases when given 600 mg/kg of moringa leaf extract compared to the addition of 300 mg/kg of moringa leaf extract. Based on the descriptive analysis above, the highest standard deviation value was obtained in the group of mice exposed to UVB and given 600 mg/kg of moringa leaf extract of 0.756.

Table 5. Average and Standard Deviation of Histopathology of Lesion Degree in SD Rats after Given Treatment

Group	Mean ± SD Histopathology Lesion Grade
Without Treatment	1.00±0.000
UVB rays	3.43±0.535
UVB+Moringa leaf extract 300 mg/kg	2.00±0.577
UVB+Moringa leaf extract 600 mg/kg	1.71±0.756

The comparison between the "UVB" and "UVB+Moringa leaf extract 600 mg/kg" groups yielding a significance value of 0.000 suggests a profound effect of moringa leaf extract in mitigating the deleterious impacts of UVB exposure. This observation aligns with research indicating the antioxidant properties of Moringa oleifera that facilitate a reduction in oxidative stress. For instance, studies have shown that Moringa oleifera can significantly decrease malondialdehyde (MDA) levels, a marker for oxidative damage, thereby supporting cellular health against UV-induced oxidative stress (Wulandari et al., 2021; Rahma et al., 2023). Additionally, the flavonoids and polyphenols present in moringa are known to exhibit antioxidant activity that neutralizes reactive oxygen species (ROS) generated by UV radiation (Othman et al., 2019). Furthermore, research has documented Moringa's efficacy in preventing oxidative injuries in various experimental models, further asserting its role in cellular protection (González-Burgos et al., 2021). Collectively, these findings corroborate the significant capability of Moringa leaf extract in countering oxidative damage linked to UVB radiation and align with the observed results.

Furthermore, the value of 0.014 between the "UVB+Moringa leaf extract 300 mg/kg" and "UVB+Moringa leaf extract 600 mg/kg" groups indicates that a higher dose of Moringa leaf extract provides a more optimal effect compared to a lower dose. This is relevant to the literature showing that different doses can provide different biological responses, and higher doses are often associated with stronger therapeutic effects (Kotyuk et al., 2016). Overall, these data suggest that treatment with moringa leaf extract, particularly at higher doses, may contribute significantly to reducing the negative effects of UVB exposure, supporting findings suggesting the benefits of plant-based therapies in the management of harmful environmental effects (Jo et al., 2023).

The results showed significant differences between the control group and the UVB-exposed group. In the control group, no specific abnormalities were found in the skin tissue, indicating a normal histological condition of healthy epidermal cells. However, in the UVB-exposed group, skin lesions of moderate to severe severity were identified, including significant damage to the stratum corneum and epidermis such as erosion and desquamation, as well as signs of apoptosis in keratinocytes. This suggests that UVB exposure can

cause dramatic damage to skin tissue that may contribute to premature aging and the development of skin cancer (Azzahra et al., 2023).

Continuing from these findings, the use of Moringa oleifera extract in groups P2 and P3 showed very promising results. In group P2, although there were some lesions showing hyperkeratosis and thickening of the epidermis, it seemed that the effect of Moringa oleifera extract had begun to alleviate the severity of the number of these lesions. In group P3, which received a higher dose of moringa extract, no specific histological abnormalities were found, indicating the efficacy of the substance in protecting the skin from UVB exposure damage (Baldisserotto et al., 2018; Gimenis et al., 2018)and strengthen the protection of delicate tissues from more extensive structural damage (Asrul et al., 2023).

Extracts from Moringa oleifera leaves are rich in phenolic and flavonoid compounds which have been shown to have strong antioxidant properties, thus having the potential to counteract oxidative stress caused by free radicals produced by exposure to UVB rays (Athikomkulchai et al., 2020; Gimenis et al., 2018). Previous studies have suggested that this compound helps in enhancing antioxidant defenses in tissues, preventing DNA damage, and repairing damage that occurs in the epidermal layer exposed to ultraviolet radiation (González-Burgos et al., 2021). In particular, flavonoids in Moringa oleifera have been associated with decreased expression of metalloproteinase proteins that support tissue damage in UV-exposed skin (Lee et al., 2018).

The presence of eosinophil infiltration found in groups P2 and P3 may also explain the increased immune response produced by the application of Moringa oleifera extract, which functions to repair damage caused by exposure to extreme environments (Proboningrat et al., 2022). In other words, the ability of Moringa oleifera to support cell regeneration and repair of skin damage can be a highly valued therapeutic potential in the development of plant-based skin care formulations (Al-Sultan & Al-Sowayan, 2024; Muthu Reka S et al., 2024).

It is interesting to note that the reported effects of Moringa oleifera have the potential to act as a preventive agent against the development of more severe skin damage due to external factors such as UV exposure. This reinforces the importance of further research to understand the molecular mechanisms involved in compounds in Moringa, as well as to develop more effective clinical applications to protect the skin against photodamage and the effects of skin aging (ELbakry et al., 2018; Gupta et al., 2012). Moringa oleifera has the potential to be a key component in skin care due to its hypoallergenic benefits and its ability to accelerate wound healing and reduce discomfort from skin irritation (Asrul et al., 2023).

Based on table 4, it was obtained that the administration of moringa leaf extract can reduce the level of lesions in male mice exposed to UVB rays. Administration of 600 mg/kg moringa leaf extract had the highest number in reducing lesions in mice with no lesions as many as 3 or 42.95, mild degree 3 (42.9%) and moderate lesion 1 (14.3%). Based on table 5, it is obtained that the highest average can be seen from the UVB group and decreases when given 600 mg/kg of moringa leaf extract compared to the addition of 300 mg/kg of moringa leaf extract. Based on the descriptive analysis above, the highest standard deviation value was obtained in the group of mice exposed to UVB and given 600 mg/kg of moringa leaf extract of 0.756. In this study, the results of the analysis of Table 4 and Table 5 show a significant impact of the administration of Moringa oleifera leaf extract on reducing the level of lesions in male mice exposed to UVB rays. Table 4 shows that the administration of Moringa leaf extract at a dose of 600 mg/kg showed the best results in reducing lesions, with the number of mice without lesions as many as 3 or 42.9%. This shows that Moringa leaf extract at this dose is very effective in reducing the negative effects of UVB radiation compared to the control (no treatment) and a lower extract dose (300 mg/kg) (Ashfaq et al., 2024; Bialangi et al., 2023).

It is important to note that only one rat in the group receiving the 600 mg/kg extract showed moderate lesions (14.3%), while the UVB control group had most of them clearly showing severe lesions (3 out of 7 rats, 42.9%). This finding is consistent with previous studies showing that moringa leaf extract has positive effects on several medical conditions related to oxidative stress and inflammation caused by external factors such as UVB light (Bialangi et al., 2023). This significant reduction indicates the potential of Moringa oleifera as a therapeutic agent to protect the skin from UVB damage.

Along with that, Table 5 provides further explanation of the average measurement and standard deviation of the histopathological lesion grade after treatment. The group exposed to UVB light without treatment had an average of 3.43 ± 0.535, which was the highest, indicating that UVB light treatment caused serious damage. Furthermore, the group receiving 300 mg/kg moringa leaf extract showed a decrease to an average of 2.00 ± 0.577, while at a dose of 600 mg/kg, the average dropped again to 1.71 ± 0.756. This indicates that stronger treatment of the extract at higher doses is proven to be beneficial (Ashfaq et al., 2024).

Descriptive analysis concluded that the highest standard deviation value was found in the group of rats exposed to UVB and given 600 mg/kg of Moringa leaf

extract (0.756), which showed greater variability in histopathological responses. This may reflect the complex effects of UVB exposure and how Moringa oleifera acts as a protective agent that interacts with cell damage (Abdel-Daim et al., 2020). Several previous studies have shown that Moringa oleifera can activate signaling pathways involved in the healing process and cell protection, indicating strong potential in cytoprotective therapy (Fahey et al., 2019).

From the above explanation, it can be concluded that Moringa oleifera has significant therapeutic benefits in alleviating skin damage caused by UVB rays, and the use of its extracts especially at higher concentrations showed better results. This finding supports further adoption and in-depth research on Moringa oleifera as a natural ingredient for protection against oxidative damage and inflammation. This is also related to other studies that show the anti-inflammatory and antioxidant potential of Moringa leaf extract, indicating the success of bioactive compounds in repairing histological damage in various parts of the body (Ali et al., 2024; Wulandari et al., 2021).

These encouraging results point to the need for further study extension to understand the basic mechanisms behind the protective effects of moringa leaf extract and its potential use in clinical therapy for diseases caused by oxidative stress.(Villarruel-López et al., 2018). Sensitive to the use of the results of this study, more attention should be paid to the various doses and concentrations of the Moringa leaf extract, as well as the potential combination with other therapies to maximize the therapeutic benefits of Moringa oleifera. There may be additional applications in skin care and health product formulation that could benefit from this discovery, particularly to combat the detrimental effects of premature aging and skin damage caused by environmental radiation (Miller et al., 2024).

Based on the available evidence, Moringa leaf extract not only has the ability to reduce UVB-induced lesions, but also shows potential in modifying oxidative stress and inflammation in animal models. Therefore, the use of Moringa oleifera in herbal medicine and research on new formulations in medicine could be an innovative and revolutionary next step for skin health and disease prevention in the future (Soekobagiono et al., 2018).

Conclusion

This study showed that Moringa oleifera leaf extract has significant potential in increasing melatonin levels and reducing UVB-induced skin damage in male Sprague Dawley rats. It was found that a dose of 600 mg/kg Moringa extract gave the most positive effect, producing the highest melatonin levels and significantly reducing skin lesions compared to the untreated control group and the UVB-only group. Histopathological results indicated that UVB exposure caused moderate to severe skin damage, while treatment with Moringa extract improved the condition, indicating the protective properties of Moringa oleifera. These findings support the use of Moringa oleifera as a therapeutic agent in dermatological practice to protect the skin from UV radiation damage. In the future, further studies are needed to understand the molecular mechanisms involved and to develop more effective Moringa oleifera-based preventive therapies to address environmental skin damage.

Acknowledgments

Thanks to the head of the Integrated Research Laboratory of Yarsi University and histology examination at the V-Stem INOVASI PRIMA laboratory and the entire student team who have assisted in this research.

Author Contributions

Concept: IR, HH,; Methodology and Software: IR, HH,; Validation and Formal Analysis: IR, HH,; Writing—Original Draft Preparation: IR, HH,; Project Administration: IR, HH,; Funding Acquisition: IR, HH.

Funding

This research received no external funding

Conflicts of Interest

The authors declare no conflict of interest

References

Abdel-Daim, M. M., Khalil, S. R., Awad, A., Abu Zeid, E. H., El-Aziz, R. A., & El-Serehy, H. A. (2020). Ethanolic Extract of Moringa oleifera Leaves Influences NF-κB Signaling Pathway to Restore Kidney Tissue from Cobalt-Mediated Oxidative Injury and Inflammation in Rats. *Nutrients*, *12*(4), 1–20. https://doi.org/10.3390/nu12041031

Abd-Elnaby, Y. A., ElSayed, I. E., AbdEldaim, M. A., Badr, E. A., Abdelhafez, M. M., & Elmadbouh, I. (2022). Anti-inflammatory and antioxidant effect of Moringa oleifera against bisphenol-A-induced hepatotoxicity. *Egyptian Liver Journal*, *12*(1), 1–8. https://doi.org/10.1186/s43066-022-00219-7

Ali, W., Khan, M. N., Nabi, G., Rahman, S. U., Sattar, S., Khan, M. F., Rahman, S. U., Zubair, S., Ain, Q. U., Sabeeh, M., & Ali, A. (2024). Effect of Moringa Leaf Extract and its Solution Application Forms on Growth and Yield of Okra. *Sarhad Journal of Agriculture*, *40*(2), 407–417. https://doi.org/10.17582/journal.sja/2024/40.2.407.417

Al-Sultan, R. M., & Al-Sowayan, N. S. (2024). The Protective Effect of Moringa oleifera</i> Leaves Extract on Paracetamol Hepatotoxicity in Male Rats. *Journal of Biomedical Science and Engineering*, *17*(03), 72–82. https://doi.org/10.4236/jbise.2024.173006

Ashfaq, S., Sajid, U., Khan, S., Saleem, Y., Batool, S. F., Zafar, S., Akber, S. S., & Sultan, S. A. (2024). Effect of Moringa Oleifera leaves powder on hemoglobin level in second-trimester pregnant women of Karachi, Pakistan. *International Journal of Endorsing Health Science Research*, *12*(1), 39–45. https://doi.org/10.29052/IJEHSR.v12.i1.2024.39-45

Asrul, N. A. M., Rivai, A. T. O., Syisnawati, S., & Haristiani, R. (2023). Ekstrak Moringa Oleifera Mempercepat Proses Penyembuhan Luka: Systematic Review. *Jurnal Farmasetis*, *12*(2), 187–194. https://doi.org/10.32583/far.v12i2.1109

Athikomkulchai, S., Tunit, P., Tadtong, S., Jantrawut, P., Sommano, S. R., & Chittasupho, C. (2020). Moringa oleifera Seed Oil Formulation Physical Stability and Chemical Constituents for Enhancing Skin Hydration and Antioxidant Activity. *Cosmetics*, *8*(1), 1–18. https://doi.org/10.3390/cosmetics8010002

Azzahra, F., Fauziah, V., Nurfajriah, W., & Emmanuel, S. W. (2023). Daun Kelor (Moringa oleifera) : Aktivitas Tabir Surya Ekstrak dan Formulasi Sediaan Lotion. *Majalah Farmasetika*, *8*(2), 133–147. https://doi.org/10.24198/mfarmasetika.v8i2.43662

Baldisserotto, A., Buso, P., Radice, M., Dissette, V., Lampronti, I., Gambari, R., Manfredini, S., & Vertuani, S. (2018). Moringa oleifera Leaf Extracts as Multifunctional Ingredients for "Natural and Organic" Sunscreens and Photoprotective Preparations. *Molecules*, *23*(3), 1–16. https://doi.org/10.3390/molecules23030664

Bialangi, A. A., Ismail, A., Purnawati, R. D., & Mundhofir, F. E. P. (2023). The Effect of Moringa Leaf Extract (moringa oleifera) on the Microscopic Structure of the Lungs of Male Wistar Rats Given Inhalation of E-cigarette Liquid Vapor. *Jurnal Kedokteran Diponegoro (Diponegoro Medical Journal)*, *12*(6), 1–7. https://doi.org/10.14710/dmj.v12i6.39824

Chengama Raju, N. S., & Siew Ying, T. (2023). Anti-Angiogenesis Screening of Moringa oleifera Pod Extracts by In-Ovo Chorioallantoic Membrane (CAM) Assay. *Hacettepe University Journal of the Faculty of Pharmacy*, *43*(4), 301–309. https://doi.org/10.52794/hujpharm.1192921

Dewi, E. D. F., Praharsini, I. G. A. A., Damayanti, P. A. A., Linawati, N. M., & Dinata, I. M. K. (2024). Administration of Arabika Coffee Leaf Extract (Coffea Arabica) Reduces Tumor Necrosis Factor Alpha (TNF-α) and Sunburn Cell Levels in Male Wistar Rats (Rattus norvegicus) Exposed to Ultraviolet-B Rays. *International Journal Of Scientific Advances*, *5*(1), 191–194. https://doi.org/10.51542/ijscia.v5i1.31

Elbakry, K., Elarabany, N., & Behery, S. (2018). Protective and Therapeutic Effects of Moringa Oleifera Against Toxicity of Lead Chloride. *Scientific Journal for Damietta Faculty of Science*, *8*(1), 11–18. https://doi.org/10.21608/sjdfs.2018.194790

Fahey, J. W., Wade, K. L., Stephenson, K. K., Shi, Y., Liu, H., Panjwani, A. A., Warrick, C. R., & Olson, M. E. (2019). A Strategy to Deliver Precise Oral Doses of the Glucosinolates or Isothiocyanates from Moringa oleifera Leaves for Use in Clinical Studies. *Nutrients*, *11*(7), 1–14. https://doi.org/10.3390/nu11071547

Farid, A., El-Dewak, M., & Diab, A. (2021). Anti-apoptotic and antioxidant effects of melatonin protect spleen of whole body γ-irradiated male Sprague-dawley rats. *International Journal of Radiation Research*, *19*(4), 861–872. https://doi.org/10.52547/ijrr.19.4.12

Fatiqin, A., Amrulloh, H., Apriani, I., Lestari, A., Erawanti, B., Saputri, A., Gita, M., Fitrianti, M., Sathuluri, R. R., Kurniawan, Y. S., Wulan, Rr. M. S., & Khan, M. S. (2021). A Comparative Study on Phytochemical Screening and Antioxidant Activity of Aqueous Extract from Various Parts of Moringa oleifera. *Indonesian Journal of Natural Pigments*, *3*(2), 43–51. https://doi.org/10.33479/ijnp.2021.03.2.43

García-García, A. L., García-Machado, F. J., Borges, A. A., Morales-Sierra, S., Boto, A., & Jiménez-Arias, D. (2020). Pure Organic Active Compounds Against Abiotic Stress: A Biostimulant Overview. *Frontiers in Plant Science*, *11*(12), 1–17. https://doi.org/10.3389/fpls.2020.575829

Gimenis, J. M., Gomes, A. C., Santos, V. H. M. dos, Ferreira, P. C., Oliveira, C. A., Baby, A. R., & Gonçalves Silva, R. M. (2018). Antioxidant and photoprotective potential of Moringa oleifera Lam (Moringaceae). *Bioscience Journal*, *34*(5), 1365–1378. https://doi.org/10.14393/BJ-v34n5a2018-39845

González-Burgos, E., Ureña-Vacas, I., Sánchez, M., & Gómez-Serranillos, M. P. (2021). Nutritional Value of Moringa oleifera Lam. Leaf Powder Extracts and Their Neuroprotective Effects via Antioxidative and Mitochondrial Regulation. *Nutrients*, *13*(7), 1–15. https://doi.org/10.3390/nu13072203

Gupta, R., Mathur, M., Bajaj, V. K., Katariya, P., Yadav, S., Kamal, R., & Gupta, R. S. (2012). Evaluation of antidiabetic and antioxidant activity of *Moringa*

oleifera in experimental diabetes. *Journal of Diabetes*, *4*(2), 164–171. https://doi.org/10.1111/j.1753-0407.2011.00173.x

Jo, J., Song, Y., Yoon, D., Lee, C. G., & Won, S. (2023). Genome-wide assessment reveals a significant association between <scp> *ACSS3* </scp> and physical activity. *Genes, Brain and Behavior*, *22*(1), 1–11. https://doi.org/10.1111/gbb.12834

Kotyuk, E., Nemeth, N., Ronai, Z., Demetrovics, Z., Sasvari-Szekely, M., & Szekely, A. (2016). Association between smoking behaviour and genetic variants of glial cell line-derived neurotrophic factor. *Journal of Genetics*, *95*(4), 811–818. https://doi.org/10.1007/s12041-016-0701-7

Lailiyah, I., Prasetyawan, S., & Aulanni'am, A. (2017). Effect of Topical Aplication of Gel Aloe Vera Extract on The UVB-Induced Skin Photoaging in Hairless Rats. *The Journal of Pure and Applied Chemistry Research*, *6*(2), 96–100. https://doi.org/10.21776/ub.jpacr.2017.006.02.321

Lee, H. J., Im, A.-R., Kim, S.-M., Kang, H.-S., Lee, J. D., & Chae, S. (2018). The flavonoid hesperidin exerts anti-photoaging effect by downregulating matrix metalloproteinase (MMP)-9 expression via mitogen activated protein kinase (MAPK)-dependent signaling pathways. *BMC Complementary and Alternative Medicine*, *18*(1), 1–9. https://doi.org/10.1186/s12906-017-2058-8

Ma, Y., Jiao, J., Fan, X., Sun, H., Zhang, Y., Jiang, J., & Liu, C. (2017). Endophytic Bacterium Pseudomonas fluorescens RG11 May Transform Tryptophan to Melatonin and Promote Endogenous Melatonin Levels in the Roots of Four Grape Cultivars. *Frontiers in Plant Science*, *07*(1), 1–15. https://doi.org/10.3389/fpls.2016.02068

Meena, R., Porwal, O., Tilak, V. K., Arya, R. K. K., & Dhakar, R. C. (2020). Pharmacological Application of Moringa oleifera: A Mini Review. *International Journal of Medical Sciences and Pharma Research*, *6*(1), 1–3. https://doi.org/10.22270/ijmspr.v6i1.25

Miller, G., Necessary, K., Burchell, R., Iwase, Y., Lautensack, N., Russell, B., Holder, E., Knee, E., & Sattley, M. (2024). Positive effects of Moringa oleifera and Moringa stenopetala seed and leaf extracts against selected bacteria. *Fine Focus*, *10*(5), 58–73. https://doi.org/10.33043/FF.10.1.58-73

Othman, A. I., Amer, M. A., Basos, A. S., & El-Missiry, M. A. (2019). Moringa oleifera leaf extract ameliorated high-fat diet-induced obesity, oxidative stress and disrupted metabolic hormones. *Clinical Phytoscience*, *5*(1), 48–57. https://doi.org/10.1186/s40816-019-0140-0

Padumanonda, T., & Johns, J. (2013). Determination of melatonin content in traditional Thai herbal remedies used as sleeping aids. *Planta Medica*, *79*(13), 1–5. https://doi.org/10.1055/s-0033-1352420

Proboningrat, A., Plumeriastuti, H., Utama, S., Sudjarwo, S. A., Legowo, D., Luqman, E. M., & Widjiati, M. (2022). Effect of Moringa oleifera leaf extract on the Histopathological Features of Testicular SeminiferousTubules of Mice (Mus musculus) Exposed to Methylmercury. *Ecology, Environment and Conservation*, *28*(1), 233–237. https://doi.org/10.53550/EEC.2022.v28i01.031

Rahma, R., Hadju, V., Arsin, A. A., Syam, A., Mallongi, A., Lewa, Abd. F., Harun, H., & Miranti, M. (2023). The Effect of Moringa Leaf Extract Intervention Since Preconception Period on the Prevention of Oxidative Stress in Pregnant Women and Adverse Pregnancy Outcomes. *Pharmacognosy Journal*, *15*(2), 310–314. https://doi.org/10.5530/pj.2023.15.45

Reka S, M., & Vijayanchali, S. S. (2024). The role of Moringa oleifera pods, seeds, bark and root as functional food. *World Journal of Advanced Research and Reviews*, *21*(3), 1937–1942. https://doi.org/10.30574/wjarr.2024.21.3.0933

Shi, L., Chen, Y., Dong, W., Li, S., Chen, W., Yang, Z., & Cao, S. (2024). Melatonin delayed senescence by modulating the contents of plant signalling molecules in postharvest okras. *Frontiers in Plant Science*, *15*(3), 1–11. https://doi.org/10.3389/fpls.2024.1304913

Soekobagiono, S., Salim, S., Hidayati, H. E., & Mundiratri, K. (2018). Effects of Moringa oleifera leaf extract combined with DFBBX on type-1 collagen expressed by osteoblasts in the tooth extraction sockets of Cavia cobaya. *Dental Journal*, *51*(2), 86–90. https://doi.org/10.20473/j.djmkg.v51.i2.p86-90

Tiwari, R. K., Lal, M. K., Kumar, R., Chourasia, K. N., Naga, K. C., Kumar, D., Das, S. K., & Zinta, G. (2021). Mechanistic insights on melatonin-mediated drought stress mitigation in plants. *Physiologia Plantarum*, *172*(2), 1212–1226. https://doi.org/10.1111/ppl.13307

Villarruel-López, A., López-de la Mora, D. A., Vázquez-Paulino, O. D., Puebla-Mora, A. G., Torres-Vitela, M. R., Guerrero-Quiroz, L. A., & Nuño, K. (2018). Effect of Moringa oleifera consumption on diabetic rats. *BMC Complementary and Alternative Medicine*, *18*(1), 1–10. https://doi.org/10.1186/s12906-018-2180-2

Wulandari, L. P., Santoso, B., & Purwanto, B. (2021). Effect of Moringa Oleifera Leaf Extract on Oxidative Stress and Theca Cell in Polycystic Ovary Syndrome Model with Insulin Resistance. *Medico Legal Update*, *21*(2), 744–749. https://doi.org/10.37506/mlu.v21i2.2771

Xie, L.-L., Li, S.-S., Fan, Y.-J., Qi, M.-M., & Li, Z.-Z. (2022). Melatonin alleviates traumatic brain injury-induced anxiety-like behaviors in rats: Roles of the protein kinase A/cAMP-response element binding signaling pathway. *Experimental and Therapeutic Medicine*, *23*(4), 1–12. https://doi.org/10.3892/etm.2022.11173