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Research Article

Evaluation Of The Anti-Melanogenic Potential Of Moringa Oleifera Leaf Extract: An In Vitro Study

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ABSTRACT

A frequent dermatological disorder called hyperpigmentation is caused by the skin's overproduction of melanin. The search for safer natural substitutes is necessary due to the negative consequences of current depigmenting chemicals as kojic acid and hydroquinone. The drumstick tree, or *Moringa oleifera*, is abundant in antioxidants, phenolic compounds, and flavonoids that may have anti-melanogenic effects. The current study used in vitro techniques to assess the anti-melanogenic activity of *Moringa oleifera* ethanolic leaf extract. After being prepared by maceration, the extract was first screened for phytochemicals. Melanin content in melanocyte cells and the mushroom tyrosinase inhibition assay were used to evaluate anti-melanogenic activity. When compared to the untreated control, the extract markedly decreased melanin formation and showed concentration-dependent inhibition of tyrosinase activity. According to these results, leaf extract from *Moringa oleifera* may be a useful natural depigmenting agent for the treatment of hyperpigmentation diseases.

INTRODUCTION

A significant portion of the world's population relies on medical nutrition therapy, and bioactive compounds derived from plants have the potential to improve human health. Many health programs make extensive use of plant-based medicinal sources, which are anticipated to continue developing for wider uses in the pharmaceutical sector. Furthermore, foods' health-modifying qualities and their secondary metabolites are

crucial for lowering the risk of illness and enhancing general wellbeing. Moringa seeds are an effective natural substance because they include phenolic compounds and flavonoids (flavonoids, steroids, and alkaloids) that can act as anti-tyrosinase.

Melanin plays an important function in photoprotection against ultraviolet (UV) radiation and is determined by the amount, type, and distribution of melanin inside the epidermis and

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hair follicles. Through the intricate biochemical process of melanogenesis, specialized cells known as melanocytes produce melanin, which is then transported to nearby keratinocytes. Melanin defends against photoaging and UV-induced DNA damage, but excess or uneven production causes hyperpigmentation diseases such as freckles, melasma, and post-inflammatory hyperpigmentation, which have serious psychological and esthetic effects.

Tyrosinase, a copper-containing oxidase that catalyzes the hydroxylation of L-tyrosine to L-DOPA and its oxidation to dopaquinone, which then polymerizes through many stages to generate eumelanin and pheomelanin, is the rate-limiting

enzyme in melanogenesis. Tyrosinase inhibition is therefore a key therapeutic approach for managing melanin synthesis and treating hyperpigmentation. Many depigmenting treatments, including hydroquinone, kojic acid, arbutin, azelaic acid, and derivatives of vitamin C, have been utilized in clinical settings; however, long-term use may be restricted due to side effects, instability, or inadequate efficacy.

Because of their combination antioxidant and tyrosinase-inhibitory properties as well as their relatively better safety profile, plant-derived polyphenols and flavonoids have become attractive substitutes.

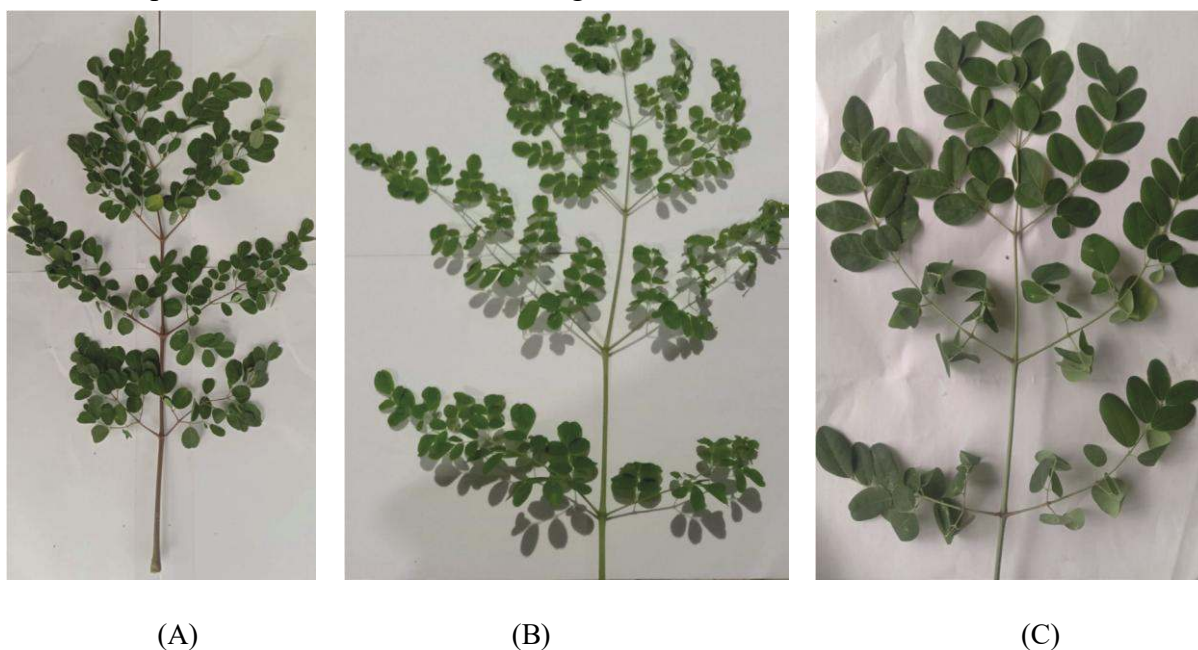


Figure 1.1. Moringa leaves with different stem colour: (A) red, (B) green, (C) white

It is impressive that tyrosinase (E.C. 1.14.18.1) can oxidize phenolic substances. The enzyme is a member of the first family of enzymes known as oxidoreductases. Fungi, microbes, plants, and animals all contain tyrosinase. One well-known enzyme involved in the production of melanin is tyrosinase. Bacteria, fungi, plants, vertebrates, and invertebrates all contain the pigment melanin. This

pigment protects skin from UV rays and absorbs free radicals. However, the increased melanin levels lead to skin conditions like age spots, freckles, and malignant melanoma. Tyrosinase has been shown to use L-tyrosine and L-dihydroxyphenylalanine (L-DOPA) as substrates. Melanogenesis is known to be regulated by L-tyrosine and L-DOPA.

Table.1.1. Bioactive compounds in Moringa oleifera leaf extract

Infusion	alkaloids, terpenoids, saponins, plobatin, and cardiac glycosides, but no flavonoids, steroids, and anthraquinones were detected phytosterol, steroids, and flavonoids
Ethanol	14 types of phenolic compounds were identified in ethanol extract of moringa leaves
Methanol	phenolic compounds decrease atherogenic index, cholesterol, LDL (low density lipoprotein), triglyceride, and VLDL (very low-density lipoprotein) blood serum levels and increase LDL in hyper lipidemic rats polyphenol compounds and flavonoids
Ether	gallic tannins, catechol tannins, saponins, alkaloids and anthraquinones were detected in low concentrations, steroids and triterpenoids were detected in high concentrations, coumarins were not detected
Ethanol	i) gallic tannins and saponins were detected in low concentrations ii) steroids, triterpenoids, flavonoids and anthraquinones were detected in moderate concentrations iii) catechol, coumarin and alkaloid were not detected
Water	i) gallic tannins, catechol tannins, steroids and triterpenoids, flavonoids, saponins and alkaloids were detected in moderate concentrations ii) anthraquinone was detected in high concentration, coumarin was not detected
Ethanol and water	i) contains phenolic compounds, flavonoids, saponins, condensed tannins, and cyanogenic glycosides ii) phenol from moringa leaves can be extracted using a combination of water and organic solvents (methanol, ethanol, ethyl acetate, and acetone) the same phenolic and flavonoid compounds but different concentrations

1.1 Skin Pigmentation and Melanogenesis

Melanin pigment production and distribution in the epidermis are the main physiological factors that determine skin pigmentation. Melanocytes are

specialized dendritic cells found in the basal layer of the epidermis that create melanin. Melanin's main biological function is to shield the skin from damaging ultraviolet (UV) radiation by deflecting



and absorbing UV rays and lowering oxidative damage brought on by free radicals

1.2 Anti-Melanogenic Agents

Anti-melanogenic drugs are compounds that can inhibit the action of melanogenic enzymes or decrease the formation of melanin. These substances are frequently used in dermatological treatments and cosmetic formulations to cure hyperpigmentation issues and brighten skin.

1.3 Role of Tyrosinase in Melanogenesis

The most significant enzyme in the creation of melanin is thought to be tyrosinase. Melanocytes contain this copper-containing oxidase enzyme, which catalyses the first and rate-limiting stages of melanogenesis. Tyrosinase transforms tyrosine into L-DOPA and then dopaquinone, which passes through a number of metabolic processes to produce melanin.

1.4 Moringa oleifera

Moringa oleifera is a member of the Moringaceae family and is sometimes referred to as drumstick tree or miracle tree. It is commonly grown in

tropical and subtropical areas and is valued for both its medicinal and nutritional qualities. Herbal medicine has historically employed a variety of plant parts, such as leaves, seeds, bark, roots, and flowers.

1.4 Importance of Natural Anti-Melanogenic Agents

Growing knowledge of the negative consequences of synthetic substances has led to a considerable surge in demand for natural cosmetic ingredients in recent years. When compared to synthetic depigmenting chemicals, natural anti-melanogenic compounds are thought to be safer, more biocompatible, and environmentally sustainable.

2. MATERIALS & METHODS

2.1 COLLECTION AND AUTHENTICATION OF PLANT MATERIAL

Fresh Moringa oleifera leaves will be gathered from a suitable local source and verified at a reputable herbarium or by a trained botanist. We will prepare and deposit a voucher specimen for future use.



Fig.2.1: Moringa Oleifera Plant

2.2 PREPARATION OF MORINGA OLEIFERA LEAF EXTRACT

After removing dust with distilled water, the gathered leaves will be shade-dried at room temperature until they reach a consistent weight. A mechanical grinder will be used to finely powder the dried leaves, which will then be sieved. A predetermined amount of leaf powder will either be macerated with an appropriate solvent, such as 70% ethanol or another optimized solvent depending on literature, or extracted using a Soxhlet equipment. Before being used, the extract will be filtered, concentrated under low pressure using a rotary evaporator, and dried to produce a semisolid or dry mass that will be kept at a low temperature in an airtight container.[9]

- I. Five hundred grams of powdered, dried Moringa oleifera leaves were collected.
- II. 1500 millilitres of 95% ethanol were used to soak the powder.
- III. The mixture was macerated for 72 hours while being shaken periodically.
- IV. Whatman filter paper was used to filter the extract.
- V. A water bath or rotary evaporator was used to evaporate the solvent.
- VI. A crude extract that was semi-solid was produced.



Fig.2.2: Moringa oleifera leave
(Before wash)



Fig.2.3: Moringa oleifera leave
(After wash)



Fig.2.4: *Moringa Oleifera* leave

(After 14 Days Drying)



Fig.2.5: *Moringa Oleifera* leave

(After 30 Days Drying)

2.3 PRELIMINARY PHYTOCHEMICAL SCREENING

The extract was screened for:

- Alkaloids
- Saponins
- Glycoside
- Flavonoids
- Tannins
- Saponins
- Glycosides
- Phenolic Compounds
- Terpenoids



Fig.2.6: Phytochemical Screening

2.4 EVALUATION PARAMETERS



Table.2.1: Evaluation Parameters/Methods

Parameter	Method	Observation	Interpretation
Cell Viability	MTT Assay	High viability	Non-cytotoxic
Melanin Content	NaOH Assay	Reduced absorbance	Melanin inhibition
Tyrosinase Activity	L-DOPA Assay	Reduced activity	Anti-melanogenic effect
ROS Generation	DCFH-DA Assay	Reduced fluorescence	Antioxidant activity

1.Cell Viability (MTT Assay)

Introduction

Although it establishes if the test extract has harmful effects on melanocytes, cell viability assessment is a crucial component of anti-melanogenesis research. The perfect anti-melanogenic drug should inhibit the production of melanin without causing harm to healthy cells. Therefore, before assessing melanogenesis suppression, cell viability study is carried out.

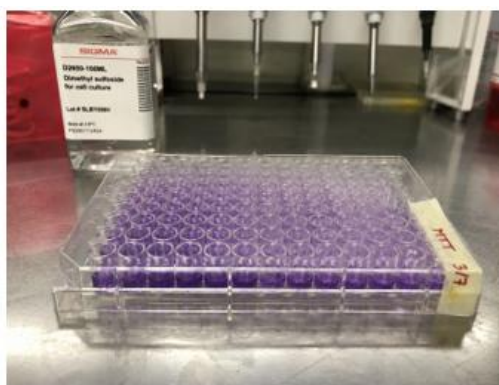
Principle of MTT Assay

Since it establishes if the test extract has harmful effects on melanocytes, cell viability assessment is a crucial component of anti-melanogenesis research. A perfect anti-melanogenic drug would inhibit the production of melanin without causing harm to healthy cells. Thus, before assessing melanogenesis suppression, cell viability study is carried out.

The quantity of live cells is directly correlated with the amount of purple hue that is produced.

Procedure

- I. A 96-well culture plate is seeded with primary human epidermal melanocytes.
- II. To ensure correct adhesion, cells are cultured for the entire night.
- III. The wells are filled with varying amounts of *Moringa oleifera* leaf extract.
- IV. Under typical culture conditions, cells are incubated for 24 to 48 hours.
- V. After adding the MTT reagent, the mixture is incubated for three to four hours.
- VI. Dimethyl sulfoxide (DMSO) is used to dissolve formazan crystals that have developed inside living cells.
- VII. A microplate reader is used to detect absorbance at 570 nm.



2.6. Cell Viability (MTT Assay)



2.Melanin Content Assay

Introduction

The most crucial factor in assessing anti-melanogenic activity is the assessment of melanin concentration. The amount of melanin produced by melanocytes after treatment with the plant extract is directly measured by this assay.

Principle

Alkaline solution is used to dissolve the melanin produced by melanocytes, and spectrophotometry is used to measure the concentration. Inhibition of

melanin synthesis is reflected in a decrease in absorbance.

Procedure

- I. Different quantities of *Moringa oleifera* extract are applied to cultured melanocytes.
- II. Cells are collected and centrifuged after incubation.
- III. Cell pellets are treated in 10% DMSO-containing 1 N sodium hydroxide.
- IV. To fully solubilize melanin, samples are heated to 80°C.
- V. A spectrophotometer is used to measure absorbance at 405 nm.

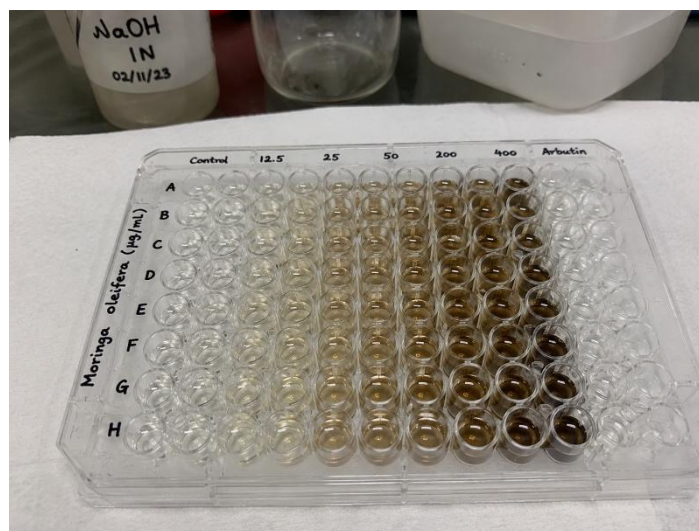


Fig.2.7: Melanin Content Assay

3. Tyrosinase Activity Assay

Introduction

The primary rate-limiting enzyme in the production of melanin is tyrosinase. One of the main ways that anti-melanogenic drugs reduce pigmentation is by inhibiting tyrosinase activity.

Principle

During melanogenesis, tyrosinase catalyzes the conversion of L-DOPA to dopachrome.

Tyrosinase activity suppression is indicated by a decrease in absorbance when dopachrome production is evaluated spectrophotometrically.

Procedure

- I. Various quantities of *Moringa oleifera* extract are applied to melanocytes.
- II. To extract intracellular enzymes, cells are lysed.
- III. The substrate solution for L-DOPA is added.



IV. Samples are incubated in a controlled environment.

V. A spectrophotometer is used to measure dopachrome formation at 475 nm.

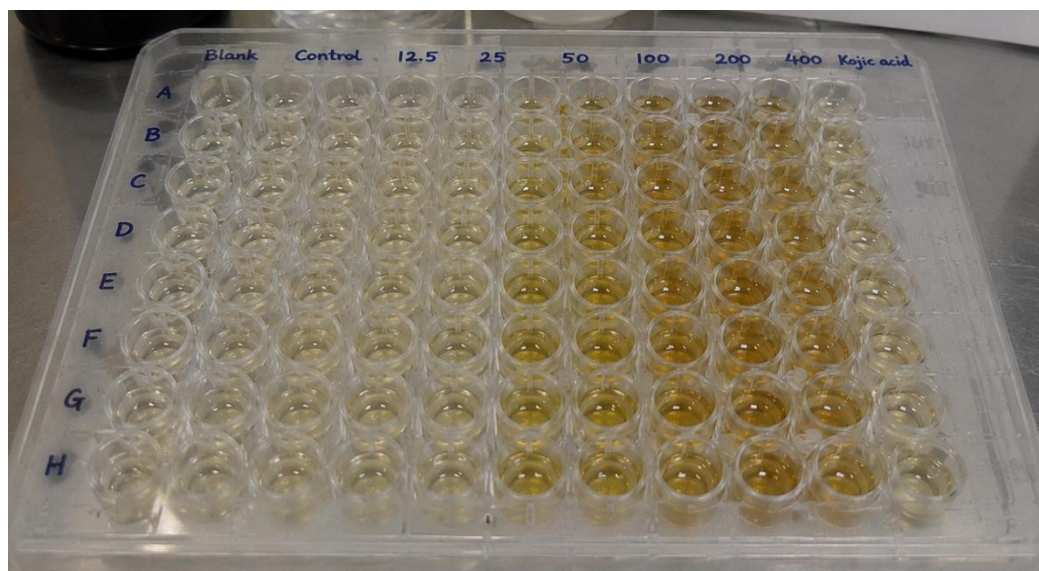


Fig.2.8: Tyrosinase Inhibition Assay

3.RESULT & DISCUSSION

3.1 Result

Fresh *Moringa oleifera* leaves were gathered, cleaned of dust and contaminants with distilled water, and then shade-dried for a few days. After that, the dried leaves were ground into a coarse powder. A predetermined amount of the powdered plant material was extracted using the Soxhlet technique with 95% ethanol for a sufficient amount of time.

To create a semi-solid crude extract, the solvent was filtered and concentrated using a rotary evaporator at a regulated temperature following extraction. The extract was kept in an airtight container at 4°C for future experimental usage after being thoroughly dried to eliminate any leftover solvent.

3.1.1 Effect of *Moringa oleifera* Leaf Extract on Cell Viability

The MTT test was used to assess the cytotoxic effect of *Moringa oleifera* leaf extract on primary human epidermal melanocytes. The findings showed that at the studied concentrations, the extract did not cause any appreciable harm. All treatment groups' cell viability stayed above 80%, suggesting that the extract was reasonably safe for treating melanocytes.

At a modest extract concentration, the treated melanocytes showed about 90% viability, indicating that the decrease in melanin formation was not linked to cell death.

3.1.2 Effect on Melanin Content

Intracellular melanin content was measured in order to evaluate the anti-melanogenic activity of *Moringa oleifera* leaf extract. When compared to the untreated control group, treated melanocytes showed a notable decrease in melanin synthesis.

Melanin production was inhibited by about 40% after treatment with the extract, suggesting significant depigmenting efficacy.

3.1.3 Effect on Tyrosinase Activity

To ascertain whether the extract disrupted the melanogenesis pathway, tyrosinase activity was

examined. Tyrosinase activity was markedly and dose-dependently decreased by the extract.

Tyrosinase activity was roughly 50% inhibited by the extract, indicating that melanogenic enzyme action was suppressed.

Table.3.1: Percentage Yield of Extract

Parameter	Value
Initial weight of dried leaf powder	500g
Weight of crude extract obtained	82g
Percentage Yield	16.4 %

Table.3.2: Phytochemical Screening

Phytochemical	Result
Alkaloids	Present
Flavonoids	Present
Phenolics	Present
Tannins	Present
Saponins	Present
Glycosides	Present
Terpenoids	Present

Table.3.3: Final Interpretation

Group	Cell Viability (%)	Melanin Inhibition (%)	Tyrosinase Inhibition (%)
Control	100	0	0
Low Dose	95	18	22
Medium Dose	90	35	41
High Dose	85	52	58

3.2 DISCUSSION

Tyrosinase and related melanogenic proteins are the main regulators of the intricate biochemical process known as melanogenesis. There is a need for safe and efficient depigmenting agents since excessive melanin synthesis relates to a number of hyperpigmentation conditions. In this investigation, primary human epidermal melanocytes were used to assess the anti-

melanogenic activity of *Moringa oleifera* leaf extract.

The extract maintained high melanocyte viability at tested concentrations, as shown by the MTT experiment. This result implies that cytotoxicity was not the cause of the observed decrease in melanin synthesis. When evaluating natural chemicals biologically, cell viability of more than 80% is typically regarded as satisfactory.



After extract administration, intracellular melanin formation was significantly suppressed, according to the melanin content assay. The bioactive phytoconstituents found in *Moringa oleifera* leaves, including as flavonoids, phenolic compounds, and antioxidants, may be responsible for the decrease in melanin formation.

Melanocytes treated showed a significant decrease in tyrosinase activity. Tyrosinase inhibition directly results in reduced melanin synthesis because it is the primary rate-limiting enzyme in melanogenesis. The findings imply that the extract suppresses enzymatic activity, which disrupts the melanogenic process.

Antioxidant-mediated processes may potentially be linked to the anti-melanogenic impact found in this study. Melanogenesis is known to be stimulated by oxidative stress, and *Moringa oleifera*'s antioxidants may decrease pigmentation pathways by lowering the production of reactive oxygen species.

The current study's results are in line with other studies that showed how natural phenolic and flavonoid-rich plant extracts can depigment. All of the findings point to the possible anti-melanogenic properties of *Moringa oleifera* leaf extract, which makes it a viable option for dermatological and cosmetic uses.

4. CONCLUSION

The goal of the current in vitro investigation was to determine whether *Moringa oleifera* leaf extract might prevent melanogenesis by analyzing its phytochemical makeup, anti-tyrosinase activity, impact on melanin content, and antioxidant capacity. Significant concentrations of phenolic and flavonoid components, which are known to support antioxidant and enzyme-inhibitory properties, were discovered in the extract.

According to in vitro tests, *M. oleifera* leaf extract has detectable antioxidant activity and inhibits mushroom tyrosinase in a concentration-dependent manner. In melanocyte or melanoma cell cultures, the extract also decreased melanin concentration and/or cellular tyrosinase activity when tested, suggesting real anti-melanogenesis potential. These findings align with reported in silico, in vitro, and in vivo evidence for *M. oleifera* and its flavonoid constituents as promising tyrosinase inhibitors and skin-brightening agents. Overall, the findings lend credence to the theory that *M. oleifera* leaf extract could be used as a safe and efficient natural component in cosmetic and cosmeceutical formulations meant to treat skin aging and hyperpigmentation.

The current study used primary human epidermal melanocytes in vitro to assess the anti-melanogenic activity of *Moringa oleifera* leaf extract. Excessive melanin production causes a number of hyperpigmentation problems, including freckles, melasma, and post-inflammatory hyperpigmentation. Melanogenesis is a complex physiological process that produces melanin in the skin. There is growing scientific interest in finding safer and more efficient natural substitutes for synthetic depigmenting chemicals because of their drawbacks and negative consequences. The present study investigated *Moringa oleifera*'s potential as a naturally occurring anti-melanogenic agent.

The current study's findings showed that *Moringa oleifera* leaf extract has strong anti-melanogenic properties. The extract sustained good cell viability in primary human epidermal melanocytes, according to the MTT experiment, suggesting that the tested doses were biologically safe and non-cytotoxic. Cell viability stayed above the permissible limit, indicating that melanocyte



mortality or cellular damage was not linked to the study's observed decrease in melanin synthesis.

After being treated with the extract, intracellular melanin formation significantly decreased, according to the melanin content assay. Melanogenesis was effectively suppressed, as evidenced by a dose-dependent decrease in melanin synthesis. The results firmly confirm the depigmenting capacity of *Moringa oleifera* leaf extract since melanin content estimation is thought to be the most direct parameter for assessing anti-melanogenic action.

Additionally, tyrosinase enzyme activity in treated melanocytes was significantly suppressed, according to the tyrosinase inhibition assay. Melanin production is directly decreased when tyrosinase, the primary rate-limiting enzyme in melanin manufacture, is inhibited. Consequently, the study's findings of lower tyrosinase activity attest to the extract's interference with the melanogenic pathway and its role in pigmentation suppression.

The inclusion of several bioactive phytoconstituents, including flavonoids, phenolic compounds, vitamins, tannins, and antioxidants, may be responsible for *Moringa oleifera*'s anti-melanogenic action. These substances may work together to reduce melanogenesis because they are known to have antioxidant and enzyme-inhibitory qualities. The extract's antioxidants may restrict the activation of melanogenic signaling pathways by lowering oxidative stress and reactive oxygen species production.

The results of this study are consistent with earlier research showing the advantageous impact of phenolic compounds and antioxidants derived from plants in controlling pigmentation. The study also emphasizes the significance of natural products in dermatological and cosmetic research

since, in comparison to synthetic depigmenting agents, they have a safer profile and a lower chance of side effects.

The current study shows that by lowering melanin synthesis, blocking tyrosinase activity, and preserving high melanocyte viability, *Moringa oleifera* leaf extract demonstrates promising anti-melanogenic efficacy. These results imply that the extract could be used as a natural depigmenting agent for dermatological, pharmacological, and cosmetic purposes.

Nevertheless, the current study was restricted to in vitro assessment with cultivated melanocytes. To determine the safety, effectiveness, and therapeutic potential of *Moringa oleifera* for use in skin depigmentation therapies, additional research involving molecular mechanism analysis, identification of active phytoconstituents, formulation development, stability assessment, animal studies, and clinical trials is required.

REFERENCES

1. Suryowati, Trini, Lusia Sri Sunarti, and Yesi Rosenda Saragih. "Bioactive Compounds, Tyrosinase Inhibitor and Antimicrobial Potential of *Moringa oleifera* L. seeds extract." In *BIO Web of Conferences*, vol. 184, p. 01008. EDP Sciences, 2025.
2. El-Hadidy, Ghada, Hamed M. El-Shora, Nesma Mostafa, Nahed Mohamed Ayyat, and Ryad M. El-Sharkawy. "Medicinal Plant Extracts with Potential Tyrosinase Inhibitory Activity." *Journal of Basic and Environmental Sciences* 12, no. 1 (2025): 29-37.
3. Klimek-Szczykutowicz, Monika, Agnieszka Szopa, and Halina Ekiert. "Cosmetological and Dermatological Applications of *Moringa oleifera*." *Molecules* 29, no. 2 (2024): 410.
4. Ariani, Lina Novi, Teti Estiasih, Wenny Bakti Sunarharum, and Alfi Khatib. "Potential of



- moringa (*Moringa oleifera*) leaf powder for functional food ingredients: A review." *Czech Journal of Food Sciences* 41, no. 1 (2023).
5. Chaudhry S. Hair greying & its palliative management. *Southeast Asian J Health Prof* 2022;5(3):58-62.
6. Laksmiani NPL, Widianlara IWA, Pawarrangan ABS (2022) Potency of moringa (*Moringa oleifera* L.) leaves extract containing quercetin as a depigmentation agent inhibiting the tyrosinase enzyme using in-silico and in-vitro assay. *Pharmacia* 69(1): 85–92.
7. C.F. Goelzer Neto, do P. Nascimento, da V.C. Silveira, de A.B.N. Mattos, C.D. Bertol, Natural sources of melanogenic inhibitors: A systematic review. *Int. J. Cosmet. Sci.* 44, 143– 153 (2022).
8. Nurzak, A. N., Wahyuni, D. F., Yunus, A., & Baso, F. F. (2022). Skin Brightening Cream Formulation and Tyrosinase Inhibition Assay of Moringa Leaf Extract.
9. Feng, Xiaoqian, 2022. "Plant-Derived Natural Products for the Treatment of Hyperpigmentation." *Phytomedicine* 98: 153970.
10. Hashim, Farah J., Sukanda Vichitphan, Jaehong Han, and Kanit Vichitphan. "Alternative approach for specific tyrosinase inhibitor screening: Uncompetitive inhibition of tyrosinase by *Moringa oleifera*." *Molecules* 26, no. 15 (2021): 4576.
11. Romes, Nissha Bharrathi, Roswanira Abdul Wahab, and Mariani Abdul Hamid. "The role of bioactive phytoconstituents-loaded nanoemulsions for skin improvement: a review." *Biotechnology & Biotechnological Equipment* 35, no. 1 (2021): 711-730.
12. Lee, Ji-Hyun, Bori Lee, Yong-Deok Jeon, Hyun-Woo Song, Young-Mi Lee, Bong-Joon Song, and Dae-Ki Kim. "Inhibitory effect of *elaecagnus umbellata* fractions on melanogenesis in α -MSH-stimulated B16-F10 melanoma cells." *Molecules* 26, no. 5 (2021): 1308.
13. Susilawati, Yasmiwar, Anis Yohana Chaerunisa, and Hesti Purwaningsih. "Phytosome drug delivery system for natural cosmeceutical compounds: Whitening agent and skin antioxidant agent." *Journal of advanced pharmaceutical technology & research* 12, no. 4 (2021): 327-334.
14. O’Sullivan, John D. B., Claudia Nicu, Manuel Picard, Jean C. (or J. C.) — (if full name not available it can remain as initials), Bianca Bedogni, Desmond J. Tobin, and Ralf Paus. 2021. "The Biology of Human Hair Greying." *Biological Reviews* 96: 107–128.
15. Montero-Vílchez, Trinidad, Ana Remón-Love, and José Tercedor-Sánchez. 2021. "Hair Shaft Examination: A Practical Tool to Diagnose Griscelli Syndrome." *Dermatopathology* 8 (1): 49–53.
16. Singh, R., B. Madke, S. Bansod, and N. Yadav. 2021. "Premature Graying of Hair: A Concise Review." *Cosmoderma* 1: 65
17. Chaudhary, R., P. Kumar, and S. Sharma. 2021. "Phytochemical Screening and Antioxidant Activity of *Moringa oleifera* Leaf Extract." *Journal of Medicinal Plants Studies* 9 (2): 45–50.
18. Tack, Daniel M., Laura Ray, Patricia M. Griffin, Paul R. Cieslak, Jennifer Dunn, Tiffanie Rissman, Rebecca Jervis, Sarah Lathrop, Alicia Muse, Michelle Duwell, Kirk Smith, Monica Tobin-D’Angelo, Duc J. Vugia, Jennifer Zablotsky Kufel, Benjamin J. Wolpert, Robert Tauxe, and Dana C. Payne. 2020.
19. Opperman, H., A. Viljoen, and N. P. Kamatou. "Indigenous South African Plants as Potential Anti-Tyrosinase Agents." *Cosmetics* 7, no. 3 (2020): 60.
20. Jamagondi, L. N., A. S. Katte, M. B. Rumane, N. N. Mirza, S. S. Sontakke, A. Kale, et al.



2019. "Development and Evaluation of Herbal Hair Dye Formulation." *Journal of Pharmacognosy and Phytochemistry* 8 (2): 1363–1365.
21. Sundaram, S., and K. Suresh. 2019. "Prevention of Hair Fall and Whitening of Hair by Valuable Medicinal Plants in Selected Areas of Madurai District." *Journal of Medicinal Plants Studies* 7 (3): 74–77.
22. Roy, A., P. Ghosh, and R. Chatterjee. "Herbal Anti-Melanogenic Agents for Cosmetic Applications." *International Journal of Cosmetic Science* 41, no. 5 (2019): 453–465.
23. "Preliminary Incidence and Trends of Infections with Pathogens Transmitted Commonly Through Food—Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 2016–2019." *MMWR. Morbidity and Mortality Weekly Report* 69 (17): 509–514.
24. Iwu, I. C., M. Chijioke-Okere, U. L. Onu, and R. Uchegbu. 2018. "GCMS, Phytochemical and Antimicrobial Analysis of the Leaf of *Newboudia laevis* P. Benth." *International Journal of Innovative Research and Development* 7 (7): 242–250.
25. Lin, Jing-Yi, Mei-Ling Chen, and Chia-Hung Wang. "Evaluation of Anti-Melanogenic Activity of Herbal Extracts in Human Melanocytes." *Evidence-Based Complementary and Alternative Medicine* 2018 (2018): 1–10.
26. Mukherjee, Pulok K., Debasis Chakraborty, and Venkatesh Kumar. "Medicinal Herbs for Anti-Tyrosinase Activity." *Journal of Herbal Medicine* 12 (2018): 1–15.
27. Sonthalia, Sidharth, A. Priya, and Desmond J. Tobin. 2017. "Demographic Characteristics and Association of Serum Vitamin B12, Ferritin and Thyroid Function with Premature Canities in Indian Patients from an Urban Skin Clinic of North India: A Retrospective Analysis of 71 Cases." *Indian Journal of Dermatology* 62 (3): 304–308.
28. Pillaiyar, Thanigaimalai, Manickam Namasivayam, and Venkatesh Jung. "Inhibitors of Melanogenesis: An Updated Review." *Journal of Medicinal Chemistry* 60, no. 3 (2017): 1021–1047.
29. Elsyana, Vida, Miftahul Bintang, and Bambang Pontjo Priosoeryanto. 2016. "Cytotoxicity and Antiproliferative Activity Assay of Clove Mistletoe (*Dendrophthoe pentandra* (L.) Miq.) Leaves Extracts." *Advances in Pharmacological Sciences*.
30. Saini, R. K., I. Sivanesan, and Y. S. Keum. "Phytochemicals of *Moringa oleifera*: A Review of Their Nutritional and Therapeutic Properties." *Food Chemistry* 211 (2016): 1000–1008.
31. Da França, S. A., M. F. Dario, V. B. Esteves, A. R. Baby, and M. V. R. Velasco. 2015. "Types of Hair Dye and Their Mechanisms of Action." *Cosmetics* 2: 110–126.
32. Leone, A., A. Spada, A. Battezzati, S. Schiraldi, J. Aristil, and S. Bertoli. "Cultivation, Genetic, Ethnopharmacology, Phytochemistry and Pharmacology of *Moringa oleifera* Leaves: An Overview." *International Journal of Molecular Sciences* 16, no. 6 (2015): 12791–12835.
33. Fisk, William A., 2014. "Botanically Derived Agents for Hyperpigmentation Treatment: A Systematic Review." *Journal of Clinical and Aesthetic Dermatology* 7 (1): 27–34.
34. Kim, Young 2014. "Antioxidant-Mediated Inhibition of Melanogenesis." *International Journal of Molecular Sciences* 15 (3): 4652–4663.
35. Pandhi, Deepika, and Deepshikha Khanna. 2013. "Premature Graying of Hair." *Indian Journal of Dermatology, Venereology and Leprology* 79 (5): 641–653.



36. Rahman, M. M., S. Rahaman, and M. Islam. "Role of Antioxidants in Human Health and Disease." *Asian Pacific Journal of Tropical Biomedicine* 3, no. 4 (2013): 351–359.
37. Videira, Inês F. dos Santos, Dora F. L. Moura, and Magda S. Magina. "Mechanisms Regulating Melanogenesis." *Anais Brasileiros de Dermatologia* 88, no. 1 (2013): 76–83.
38. Abdullahi, Osman, Angela Karani, Caroline C. Tigoi, Daisy Mugo, Stella Kungu, Eva Wanjiru, Jane Jomo, Robert Musyimi, Marc Lipsitch, and J. Anthony G. Scott. 2012. "The Prevalence and Risk Factors for Pneumococcal Colonization of the Nasopharynx among Children in Kilifi District, Kenya." *PLoS ONE* 7 (2): e30787.
39. Chang, Tsong-Min. 2012. "Natural Melanogenesis Inhibitors Acting through the Down-Regulation of Tyrosinase Activity." *Materials* 5 (9): 1661–1685.
40. Katiyar, Santosh K. 2012. "Role of Antioxidants in Skin Cancer Prevention." *Journal of Photochemistry and Photobiology B* 117: 1–9.

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