RESEARCH PAPER

Comparative Efficacy of Mandelic Acid Peel versus Topical Kojic Acid 2% in the Treatment of Periorbital Melanosis

Sai Shiva Ram Meda [1], Neha Mariam Joseph [1], Mythileeswari Lakshmikanthan [2], Thirumurugan Ayyadurai [2], Sakthivel Muthu [3]*

[1] Department of Dermatology, Saveetha Medical College and Hospital (SMCH), Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India; medasaishivaram@gmail.com (S.S.R.M) and nehajoe93@gmail.com (N.M.J).
[2] Department of Research, Saveetha College of Nursing (SCON), Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India; mythileeswari@gmail.com (M.L) and anbubot373@gmail.com (T.A).
[3] Natural Biomedicine Laboratory, Department of Dermatology, Saveetha Medical College and Hospital (SMCH), Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India; saktthivel@gmail.com (S.M).

*** Corresponding author :** saktthivel@gmail.com (S.M).

Abstract

Background: Periorbital melanosis (dark circles under the eyes) is a common cosmetic concern that can negatively affect appearance and psychological well-being. Various therapeutic approaches have been explored in cosmetic dermatology for its management. Mandelic acid, an alpha-hydroxy acid derived from bitter almonds, promotes gentle exfoliation and inhibits melanin synthesis, while kojic acid primarily acts as a tyrosinase inhibitor that reduces melanogenesis. Although both agents are widely used in treating hyperpigmentation disorders, comparative clinical evidence regarding their effectiveness in periorbital melanosis remains limited.

Objectives: This study aimed to compare the clinical efficacy, safety, and patient satisfaction of a 40% mandelic acid chemical peel with 2% topical kojic acid cream in patients with periorbital melanosis. The study also evaluated changes in pigmentation severity, lesion color characteristics, and overall improvement using standardized clinical grading and a visual analogue scale (VAS) over a 12-week treatment period.

Methods: This single-center randomized parallel clinical trial included 20 adult patients with periorbital melanosis recruited from the outpatient dermatology department of Saveetha University Medical College and Hospital. Participants were randomly assigned to two groups. The intervention group received 40% mandelic acid peel applied to the periorbital area every two weeks for six sessions, while the comparator group applied 2% kojic acid cream twice daily for 12 weeks. Pigmentation was evaluated at baseline and week 12 using a 10-point VAS, standardized pigmentation grading (Grades I–IV), and color classification. Safety and tolerability were also monitored.

Results: Both groups showed significant improvement in pigmentation after treatment. However, the mandelic acid peel group demonstrated greater clinical improvement, with 40% of patients achieving Grade I reduction and a greater shift toward lighter pigmentation compared with the kojic acid group. VAS scores were significantly higher in the mandelic acid group ($p < 0.05$). Both treatments were well tolerated, with only mild transient erythema reported and no serious adverse events.

Conclusion: Both 40% mandelic acid peel and 2% topical kojic acid are safe and effective for treating periorbital melanosis; however, the mandelic acid peel demonstrated superior efficacy. Its combined exfoliative and anti-melanogenic effects may contribute to faster and more noticeable improvement.

Keywords: Periorbital Melanosis, Mandelic Acid Peel, Kojic Acid, Hyperpigmentation Treatment, Chemical Peeling

How to cite this article: Meda SSR, Joseph NM, Lakshmikanthan M, Ayyadurai T, Muthu S. Comparative Efficacy of Mandelic Acid Peel versus Topical Kojic Acid 2% in the Treatment of Periorbital Melanosis. Int J Drug Deliv Technol. 2026;16(15s): 118-123. DOI: 10.25258/ijddt.16.15s.14.

INTRODUCTION

Due to a variety of reasons, individuals with periorbital melanosis (POM), more widely known as "dark circles," may still find it difficult to find a cause for their skin condition [1]. POM may manifest itself as either hyperpigmentation in the lower eyelid or the mid-forehead as a result of light reflecting off the tear trough. In the past few decades, however, POM has become a larger issue and is now considered by some to be a major factor contributing to patients' psychological distress and for which many individuals seek treatment [2,3,4]. A number of different factors can contribute to the creation of POM,

*Author for Correspondence: *saktthivel@gmail.com (S.M)

including (but not limited to) genetic predisposition, dermal melanocytosis, post-inflammatory hyperpigmentation, decreased collagen production in the area of the lower eyelid, abnormal vascularity of the zone around the eye, and certain lifestyle variables (that include chronic sleep deprivation, increased screen time and exposure to UV radiation) [5,6,7]. All of these factors can interact with one another to create POM, making it fairly complicated to treat and requiring development of a custom approach to treatment depending on which of these factors had a significant influence on the creation of the POM.

Treatment modalities available for POM include the use of topical depigmenting agents, topical hydroquinone, use of chemical peels and ablative laser procedures, including the use of soft tissue fillers. Hydroquinone has long been considered the gold standard topical treatment for POM, but due to its potential to cause exogenous ochronosis or irritation (particularly in individuals with higher Fitzpatrick skin types found in South Asia) and the search for a safer alternative have led to other topical options being evaluated [8,9]. Kojic acid is a fungal product that inhibits tyrosinase and has gained acceptance as an effective treatment for melasma and other hyperpigmented disorders. It works by preventing the conversion of tyrosine to melanin.

Chemical peeling has become a staple in the treatment of epidermal pigmentary disorders. Chemicals such as glycolic acid and lactic acid (alpha hydroxyl acids, or AHAs) are frequently used for chemical peeling, but their effectiveness in the sensitive periorbital area is limited due to the potential for irritation. Mandelic acid, an aromatic AHA produced from bitter almonds, has a different profile than AHAs. Its larger molecular weight allows for slower and more controlled penetration, which increases its safety in sensitive areas. In addition to its keratolytic effect, mandelic acid has direct antityrosinase activity, making it unique in providing dual benefits to both exfoliate pigmented keratinocytes and decrease de novo melanogenesis. Although the role of both kojic acid and mandelic acid is well established in the field of dermatology, there continues to be a significant gap in the literature regarding a direct and controlled trial comparing the efficacy and safety of each agent specifically for the treatment of periorbital melanosis. There have been previous studies evaluating these agents individually or for broader indications such as melasma; however, the unique anatomical and physiologic characteristics of the periorbital region (thinner epidermis, increased vascularity, and higher rates of patient-reported sensitivity) warrant independent evaluation.

Thus, as there are no existing studies to guide the clinician regarding whether to use an easy, patient-applied topical agent or a more intense, office-based procedure to treat periorbital melanosis, the objective of this study was to perform a rigorous head-to-head comparison of the clinical efficacy, quality-of-life improvement, and safety between the two treatments. Using both patient-reported outcome measures and objective clinical grading, this study will generate strong data to assist the clinician make informed treatment decisions and provide optimal patient outcomes for this common cosmetic concern.

MATERIALS AND METHODS

Design and setting

We conducted a prospective, randomized, parallel, comparative trial using data from the dermatology outpatient department of Saveetah Medical College and Hospital, an academic referral center located in Chennai, India. The study was conducted over six months and received Ethical Review Board and Institutional Review Board (IRB) Approval before starting (IEC-Reference Number:013/02/2026/IEC/SMCH/Dated/24/February/2026). This study was performed in accordance with the principles outlined in the Declaration of Helsinki.

Selecting patients

All consecutive adults who presented to the investigator with bilateral periorbital melanosis as their primary complaint were evaluated for participation in the study. Participants were diagnosed with periorbital melanosis if they had visible hyperpigmented (darker) skin on their lower eyelid and/or above their upper eyelid for more than three months.

Criteria for inclusion

To participate in this study, patients had to fulfil all of the following eligibility criteria: 1) be 18 years of age or older; 2) have a clinical diagnosis of periorbital melanosis for at least three months; 3) have Fitzpatrick skin phototypes II-IV; 4) agree not to use any other depigmenting treatments or procedures during the entire duration of the study; and 5) provide written informed consent to participate in the study.Inclusion/Exclusion Criteria: Individuals were excluded from the study if they had a prior history of hypersensitivity or an allergic reaction to mandelic acid or kojic acid or any other ingredient contained in the formulations. Individuals who were pregnant or breastfeeding; those with active dermatologic conditions in the periorbital region (e.g., eczema, psoriasis, active herpes simplex); those with a history of keloid formation or poor wound healing; those who had used systemic retinoids, corticosteroids or photosensitizing drugs within the last three months; or those who had unrealistic expectations regarding treatment outcome were excluded from participating in this study.

Sample size and randomization

The exploratory nature of this study was determined to make twenty. Participants who met eligibility requirements were randomly assigned to one of the two treatment groups in a 1:1 ratio using computer-generated random numbers and sealed opaque envelopes numbered in sequence. This procedure ensured the concealment of group allocation.

Treatment protocols

Group I (Mandelic Acid Peel)

Participants treated with mandelic acid performed six chemical peel sessions using a 40% water-based mandelic acid solution, once a week for six weeks. Prior to

performing the chemical peel, the skin surrounding the periorbital area was cleansed using a mild soap-free cleanser, and the mandelic acid solution was applied with a fan brush avoiding contact with the eyelid margin and lashes. The mandelic acid solution remained on the skin for a designated time of three to five minutes, during which participants reported a mild stinging sensation. The clinical endpoints were judged to be uniform soft erythema or frosting at the conclusion of the procedure. All peels were completely neutralized with sodium bicarbonate solution at 8.4%. After finishing the peel, all patients applied a bland, non-comedogenic moisturizer and a broad-spectrum sunscreen (SPF 50+) to the treated area. They were provided sun protection counseling and warned not to pick or scratch at the treated area.

Group II (2% Kojic Acid)

A second group of participants (Group II) was given a commercially prepared formulation of stable, topical 2% kojic acid to apply to their entire periorbital area (two times daily) at cleansing in the morning and again at bedtime. Compliance with broad-spectrum sun screen use during the day was again strongly encouraged again in this group. Treatment for this group was also for a continuous period of twelve weeks. Assessment methods and outcome variables for all three assessment time points (week 0, week 6, and week 12) were performed by the same blinded investigator who did not perform the treatments themselves.

Primary Outcome(s)

The primary outcome of interest was the change in severity of hyperpigmentation, which was assessed using a combination of two tools:

1. Visual analog scale (VAS)

A subjective assessment tool reported by the patients; patients reported their level of improvement by placing a mark on a straight line to indicate where they thought their hyperpigmented area was at that time. The endpoint marks are considered zero (no improvement) and ten (complete clearance), and the distance of their mark(s) from the left endpoint will be recorded as their VAS score.

2. Clinical grading scale

Investigator-derived, standardized measurement grading system (1-4) for assessing the severity of the hyperpigmentation (1 = mild; 2 = moderate; 3 = severe; 4 = very severe).

Secondary Outcome(s)

Colour assessment

The predominant color of the affected area is defined as brown, brownish-black, or black.

Global aesthetic improvement scale (GAIS)

At the conclusion of the study, the investigator and patient independently assigned the overall improvement their treated area from no improvement to significant improvement.

Safety and tolerability

All study participants were asked about the presence of any adverse effects such as erythema, burning, stinging, peeling/desquamation, dryness/roughness, and/or post-inflammatory hyperpigmentation (PIH). All of these adverse effects were graded as mild, moderate, or severe.

Statistical analysis

Using the Statistical package for the social sciences (SPSS) version 26.0, statistical analysis was conducted on all variables to obtain descriptive statistics using categorical data such as gender, improvement grades, and colour, as well as continuous data such as age and VAS scores. Categorical data were presented as frequencies and percentages for analysis using either chi-square or Fisher's exact test. Continuous data were expressed using the mean plus or minus the standard deviation (SD) with comparisons made between groups with an independent sample's t-test or Mann-Whitney U test, depending on the Shapiro-Wilk test results for normality distribution. VAS scores intra-group were analysed using repeated-measures ANOVA. A two-tailed p-value of less than 0.05 was considered a statistically significant result.

RESULTS

A total of twenty patients (6 males, 14 females) completed the study protocol with full adherence. The mean age of participants was 26.25 ± 5.7 years, and the mean duration of periorbital melanosis was 9.3 ± 8.1 months. As detailed in Table 1, the two randomized groups were well-matched at baseline with no statistically significant differences in terms of age, gender distribution, duration of illness, initial clinical grading, or color of pigmentation ($p > 0.05$ for all parameters).

Table 1. Baseline demographic and clinical characteristics of the study participants

Characteristic	Kojic Acid Group (n=10)	Mandelic Acid Peel Group (n=10)	p-value
Age (years), Mean ± SD	26.5 ± 6.2	26.0 ± 5.4	0.849
Gender, n (%)			1.000
Male	3 (30%)	3 (30%)	
Female	7 (70%)	7 (70%)	
Duration of POM (months), Mean ± SD	12.1 ± 9.8	6.9 ± 5.1	0.219
Baseline clinical grade, n (%)			1.000
Grade I	1 (10%)	1 (10%)	

Grade II	3 (30%)	3 (30%)	
Grade III	4 (40%)	4 (40%)	
Grade IV	2 (20%)	2 (20%)	
Baseline colour, n (%)			0.880
Brown	4 (40%)	5 (50%)	
Brownish black	4 (40%)	3 (30%)	
Black	2 (20%)	2 (20%)	

Visual analog scale (VAS)

A significant improvement in VAS scores was observed from baseline to week 12 in both groups ($p < 0.001$ for within-group comparisons). However, the magnitude of improvement was significantly greater in the mandelic acid peel group. At week 12, the mean VAS score in the mandelic acid group was 7.8 ± 1.3, compared to 5.4 ± 1.6 in the kojic acid group ($p = 0.002$) (Fig. 1).

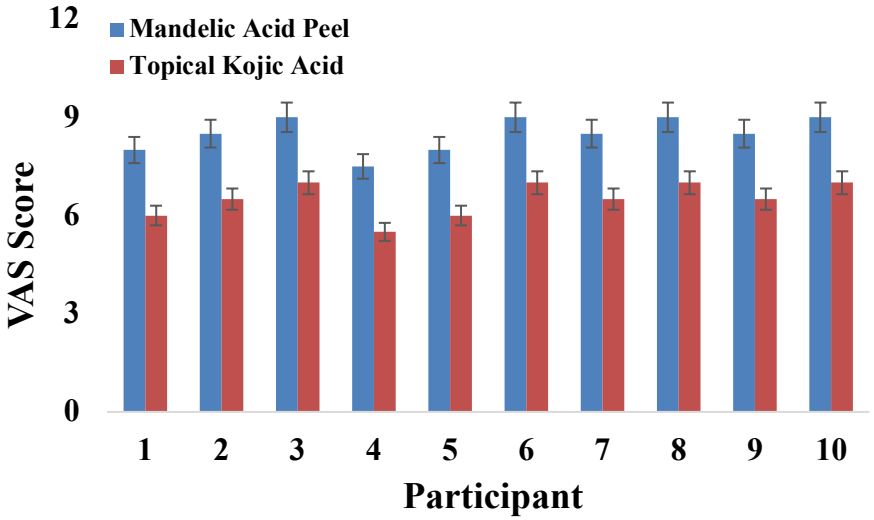

Fig 1. Patient-reported improvement (VAS Scores) in periorbital melanosis after Mandelic Acid Peel vs. Kojic Acid therapy.

Clinical grading

Post-treatment grading revealed a more favourable shift towards milder grades in the mandelic acid peel arm. The distribution of final clinical grades is presented in Table 2.

Global aesthetic improvement scale (GAIS)

The investigator's assessment using GAIS (Table 3) rated 80% of patients in the mandelic acid group as having achieved "Significant Improvement," compared to only 10% in the kojic acid group ($p = 0.004$). Patient self-assessment mirrored these findings, with 70% of the peel group reporting "Significant Improvement" versus 10% in the topical group ($p = 0.007$).

Table 2. Post-treatment distribution of clinical grades.

Final clinical grade	Kojic acid group (n=10) n (%)	Mandelic acid peel group (n=10) n (%)
Grade I	3 (30%)	4 (40%)
Grade II	4 (40%)	3 (30%)
Grade III	2 (20%)	1 (10%)
Grade IV	1 (10%)	2 (20%)

Table 3. Global aesthetic improvement scale (GAIS) assessment at week 12.

Assessment / Improvement Level	Kojic Acid Group (n=10) n (%)	Mandelic Acid Peel Group (n=10) n (%)	p-value
Investigator GAIS			0.004
Significant Improvement	1 (10%)	8 (80%)	
Moderate Improvement	4 (40%)	2 (20%)	
Mild Improvement	5 (50%)	0 (0%)	
Patient GAIS			0.007
Significant Improvement	1 (10%)	7 (70%)	
Moderate Improvement	4 (40%)	3 (30%)	

Mild Improvement	5 (50%)	0 (0%)	

Safety and tolerability

Both treatments demonstrated a favorable safety profile. Adverse events were minor and self-limiting. In the kojic acid group, two patients (20%) reported mild, transient erythema, and one (10%) developed mild post-inflammatory hyperpigmentation that resolved with continued sun protection. In the mandelic acid peel group, one patient (10%) experienced mild erythema immediately post-peel, which subsided within 24 hours. No instances of severe burning, blistering, scarring, or persistent irritation were recorded in either group. Participant compliance was excellent, with no dropouts due to adverse events.

DISCUSSION

According to the results of this randomized controlled trial, there is an apparent order of treatment effectiveness for treating periorbital melanosis with two different agents. Both the 40% mandelic acid peel and the 2% kojic acid cream showed improvement from baseline; however, the mandelic acid peel showed much greater improvement than the kojic acid cream in all assessed areas - patient satisfaction based on self-reporting, global improvement based on assessments by the investigator, and decrease in pigmentation grade based on clinical assessment. The greater success of the mandelic acid peel versus the kojic acid cream can be logically explained by looking at each agent's mode of action, pharmacokinetics for each agent, and the complex pathophysiology of periorbital melanosis (POM).

Kojic acid mainly acts by way of being a competitive inhibitor of tyrosinase, one of the rate-limiting enzymes for the production of melanin (melanogenesis). Because of this mechanism, the effectiveness of kojic acid is based largely on how deeply it penetrates the epidermis and how long the enzyme is inhibited to prevent new melanin formation [10]. The mechanism for the effectiveness of kojic acid alone does not address any of the pre-existing melanin that may already be present in the stratum corneum or surface epidermal layer. Additionally, the concentration of kojic acid used in this study (2%) is at the low end of the normal dosing range for use (1–4%), which may have affected the less than desired results. According to Chib et al. [11], there is much variability with the stability and transdermal penetration of kojic acid in topical products; thus, real-life use may be impacted by these factors. There may also have been patient-dependent factors (no consistency in application frequency, application of inadequate amounts, lack of simultaneous use of photoprotection a vital adjunct to all depigmenting regimens) that impacted the end results of using kojic acid, despite our efforts to provide continued guidance and follow-up to facilitate compliance.

In contrast, the greater efficacy of the mandelic acid peel can likely be accounted for by its multiple mechanisms of action or pharmacodynamics. When applied to the outer layer of the skin (epidermis) as an alpha-hydroxy acid, both the chemical peel and mandelic acid break down the ion bonds between skin cells and produce a degree of controlled cell death. By disrupting the ionic bonds, there is a controlled, rapid exfoliation of skin cells with pigment (keratinocytes) and an immediate “unroofing” effect on the superficial pigment. In addition, mandelic acid causes an inhibition of tyrosinase activity thereby reducing the production of new melanin. The combination of these two mechanisms makes it possible for keratinocytes to be exfoliated and to prevent the production of new pigmentation.

When mandelic acid is combined with the chemical peel, the dual mechanism of action allows the patient to receive a standardized and sufficient treatment in the office every two weeks. In this way, it prevents the variable factors involved in the successful application of topical products by the patient. The result of the chemical peel may also produce a mild/subclinical dermal tissue injury which can help in the remodeling of collagen and improving the texture of the skin so that the shadowing effect of dark circles will be minimized.

The safety record of both the chemical peel and mandelic acid has proven to be very good. The periorbital area of the body has a very thin epidermis and a high concentration of sensory nerves which makes it very susceptible to irritation, therefore, the finding of only mild/transient erythema and only one case of post-inflammatory hyperpigmentation among all the patients is a major accomplishment that provides an added level of reassurance to clinicians regarding the application of either treatment to this very sensitive area of the skin. In fact, mandelic acid is regarded as being gentle because it has a slower rate of penetration into the skin than other alpha hydroxy acids and this holds true for this particular anatomical area with minimal downtime between treatments, both modalities can be integrated into clinical practice. This is an important factor for patients.

The present research can be placed in the context of existing scientific literature to illustrate consistency and to add additional information. This study supports that kojic acid has been shown to be effective as a depigmenting agent [10,11,12] and that AHA peels for the treatment of POM have been shown to be efficacious by Dayal et al. [13]. Similarly, results presented in the present study corroborate the findings of Zeeshan et al. [14] regarding safety and efficacy of mandelic acid in the treatment of POM. While all the above-mentioned studies are of importance and contain useful information, the present study adds to the literature with completed comparative analysis between two treatment types that could enhance accuracy and credibility in therapeutic decision-making. The data provided should assist dermatologists in determining which of these options should be recommended to patients with POM.

Despite the support for this study's primary conclusion, the findings must be interpreted within the context of limitations. Although the sample size was adequate to provide statistical differences between the two treatment groups, it was modest in size. A larger, multi-centre trial would complement the generalizability of the present conclusions. The time frame of 12 weeks would be

adequate to determine initial efficacy but may be too brief to evaluate durability of the treatment and specific recurrent rates. The use of biometric objective measures (p. g., spectrophotometer [Mexameter®] or high-powered imaging analysis) would have provided more exact and less subjective data regarding the changes in pigmentation. The use of a single-blinded design (blinded assessor) was also a limitation with which all investigators must contend when comparing a procedure to a topical treatment. The inability to blind both the subject and the treating physician is an inherent limitation of trials that compare a procedure to a topical treatment [15,16].

A 40% mandelic acid peel is the most efficacious treatment for patients with periorbital melanosis as compared to 2% kojic acid cream. The magnitude of improvement is quicker with the use of mandelic acid due, in part, to its dual mechanism of exfoliation and action as an antityrosinase agent, as well as its professionalism in treatment administration to patients. Consequently, dermatologists should recommend mandelic acid peels as a first line of therapy to patients with moderate to severe POM desiring significant and rapid improvement. Patients with mild periorbital pigmentation or who desire a budget-friendly treatment can use kojic acid cream safely. Future research should focus on larger sample sizes and longer-term treatment options and alternative treatment combinations using the strengths of topical and procedural therapies to provide optimal and durable results for this troublesome but common condition.

CONCLUSION

The above trial shows a comparison of the mandelic acid peel (40%) and the Kojic acid (2%) treatment on periorbital melanosis. Both treatments demonstrated to be effective and safe in the treatment of periorbital melanosis. However, the mandelic acid peel demonstrated to have statistically significant differences in improving the PI scores of PR, COV, and P over the Kojic acid treatment. The increased efficacy of the Mandelic acid peel could be attributable to its ability to exfoliate and inhibit melanogenesis by mandelic acid. These results support the Mandelic acid peel as the first line therapy of patients seeking significant improvement of dark circles under their eyes. Future studies should use larger patient groups, longer followup periods, and direct colorimetric measurements to validate and standardize each of these treatments.

Conflict of Interest

Authors do not express any conflict of interest.

Funding

The study was not funded by any particular grant by either public, commercial, or not-for-profit funding agencies.

REFERENCES

1. Srinivasan VR, Haridass P, Wahab AJ, Harikrishnan V. An atypical case of leprosy mimicking a lichenoid eruption. Leprosy Review. 2024 Mar 1;95(1):113-7.
2. Agrawal R, Jurel P, Deshmukh R, Harwansh RK, Garg A, Kumar A, Singh S, Guru A, Kumar A, Kumarasamy V. Emerging trends in the treatment of skin disorders by herbal drugs: traditional and nanotechnological approach. Pharmaceutics. 2024 Jun 28;16(7):869.
3. Mascarenhas-Melo F, Ribeiro MM, Kahkesh KH, Parida S, Pawar KD, Velsankar K, Jha NK, Damiri F, Costa G, Veiga F, Paiva-Santos AC. Comprehensive review of the skin use of bakuchiol: Physicochemical properties, sources, bioactivities, nanotechnology delivery systems, regulatory and toxicological concerns. Phytochemistry Reviews. 2024 Oct;23(5):1377-413
4. Ranu H, Thng S, Goh BK, et al. Periorbital hyperpigmentation in Asians: an epidemiologic study and a proposed classification. Dermatol Surg. 2011;37(9):1297–1303.
5. Sarkar R. Idiopathic cutaneous hyperchromia at the orbital region or periorbital hyperpigmentation. J Cutan Aesthet Surg. 2012;5(3):183–184.
6. Sheth PB, Shah HA, Dave JN. Periorbital hyperpigmentation: a study of its prevalence, common causative factors and its association with personal habits and other disorders. Indian J Dermatol. 2014;59(2):151–157.
7. Huang YL, Chang SL, Ma L, et al. Clinical analysis and classification of dark eye circle. Int J Dermatol. 2014;53(2):164–170.
8. Friedmann DP, Goldman MP. Dark circles: etiology and management options. Clin Plast Surg. 2015;42(1):33–50.
9. Malakar S, Lahiri K, Banerjee U, et al. Periorbital melanosis is an extension of pigmentary demarcation line-F on face. Indian J Dermatol Venereol Leprol. 2007;73(5):323–325.
10. Goodman RM, Belcher RW. Periorbital hyperpigmentation. An overlooked genetic disorder of pigmentation. Arch Dermatol. 1969;100(2):169–174.
11. Sawant O, Khan T. Management of periorbital hyperpigmentation: An overview of nature-based agents and alternative approaches. Dermatol Ther. 2020;33(4):e13717.
12. Saeedi M, Eslamifar M, Khezri K. Kojic acid applications in cosmetic and pharmaceutical preparations. Biomed Pharmacother. 2019;110:582–593.
13. Noble A, Greenstein J, Husain A, Zielinski M, Hahn B. Periorbital melanosis. Am J Emerg Med. 2017;35(2):380.e1–380.e2.
14. Dayal S, Sangal B, Sahu P. Ferulic acid 12% peel: An innovative peel for constitutional type of periorbital melanosis—Comparing clinical efficacy and safety with 20% glycolic peel and 15% lactic peel. J Cosmet Dermatol. 2020;19(9):2342–2348.
15. Zeeshan M, Arfeen N, Sonthalia S, Singh A, Roy PK. Treatment of acanthosis nigricans with sequential salicylic acid-mandelic acid combination peel and maintenance with glycolic acid-urea combination cream: A retrospective pilot study. J Cosmet Dermatol. 2022;21(9):3905–3909.
16. Chib S, Jamwal VL, Kumar V, Gandhi SG, Saran S. Fungal production of kojic acid and its industrial

applications. Appl Microbiol Biotechnol. 2023;107(7-8):2111–2130.