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“Exploring the Efficacy of Niacinamide and Ascorbyl Tetraisopalmitate in Lip-Brightening Serum Formulation”

Nita Sapitri¹, Nisrina Nazhifah¹, Siva Fauziah¹, Dinda Meutiah¹, Syifa Athia Zainun Faqiha¹, Kibaek Kim¹, Young Kwan Cho¹, Jinyoung Suh² and Min Kyoung Cheong¹

¹Research and Innovation, Cosmax Indonesia, Jakarta, Indonesia; ²Research and Innovation Center, Cosmax, Pangyo, South Korea

1. Introduction

Niacinamide, also known as nicotinamide, is a water-soluble form of vitamin B3 and plays an important role in skin health. As a pyridine derivative and a precursor to the coenzymes NAD⁺ and NADP⁺, niacinamide supports cellular repair, energy metabolism, and antioxidant defense [1]. It has anti-inflammatory activity by inhibiting nitric oxide synthase (NOS) and enhancing the activity of catalase, an enzyme that helps neutralize oxidative stress [1]. Niacinamide also shows antimicrobial activity, especially helpful for oily and acne-prone skin types. It has been shown to help control sebum production, starting from concentration as low as 2% [5].

In addition, niacinamide demonstrates significant anti-hyperpigmentation properties by reducing melanin transfer from melanocytes to keratinocytes, leading to a decrease in epidermal pigmentation [2]. It also helps reduce skin yellowing caused by glycation and provides anti-aging benefits by improving skin elasticity, strengthening the skin barrier, and boosting collagen synthesis [1].

In cosmetic formulations, niacinamide is widely used due to its dual functionality as a skin barrier-strengthening and brightening agent. Due to its proven multifunctional benefits, niacinamide is now featured as a key active ingredient in nearly all modern skincare products. Its popularity is not only driven by its strong scientific backing but also by the high consumer demand, as many people start to trust its effects. This has made niacinamide a popular choice for creating effective and versatile skincare solutions.

Vitamin C is another well known natural active commonly used in cosmetic products for its powerful antioxidant, anti aging, and skin-brightening properties. It helps neutralize free radicals and improve overall skin tone. However, the application of pure vitamin C (ascorbic acid) in cosmetic formulations faces significant limitations due to its instability. It is highly susceptible to oxidation, which causes it to degrade rapidly upon exposure to light, air, and heat.

To overcome this, more stable derivatives of vitamin C have been developed. One of the most promising is Ascorbyl Tetraisopalmitate (ATIP). This is an oil-soluble and highly stable form of vitamin C that works well in oil-based formulations and remains effective even under heat. It

has excellent skin penetration and is efficiently converted into free vitamin C upon absorption, delivering similar biological effects, such as antioxidant protection and melanin synthesis inhibition [3]. Due to its enhanced stability and compatibility with various formulations, ATIP has become a promising alternative for developing advanced brightening and anti-aging cosmetic products. As vitamin C continues to be a cornerstone ingredient in skincare, the exploration of innovative and effective formulations like ATIP offers promising opportunities for expanding its application, particularly in skin brightening solutions.

Although both niacinamide and vitamin C are widely used for brightening and protecting facial and body skin, their use in lip care products is still limited. This gap exists partly because lip skin has unique anatomical and physiological characteristics. The lips are composed of a thin stratum corneum and lack hair follicles and sweat glands [5]. Additionally, the non-keratinized epithelium of the lips is directly exposed to external environmental stressors such as UV radiation, making it more vulnerable to damage.

Lip color is influenced by several factors, including melanin content, skin thickness, and blood vessel visibility. Lip hyperpigmentation is a common concern caused by genetic, hormonal changes, environmental exposure, certain medications, or trauma, which can lead to darker or uneven lip tone. However, scientific research on lip pigmentation and brightening is still very limited.

The objective of this study is to evaluate the potential of active ingredients commonly used in skin-brightening, niacinamide and ascorbyl tetraisopalmitate, for their effectiveness in brightening the lips. By using validated efficacy test, this research aims to support the development of innovative, targeted lip care solutions and contribute to the advancement of comprehensive lip-brightening formulations in the beauty industry.

2. Materials and Methods

Materials

Glycerin (Musim Mas, Indonesia), Trisodium Ethylenediamine Disuccinate (Innospec, UK), PEG-5 Glyceryl Stearate (Nihon Emulsion, Japan), 1,2-Hexanediol (Symrise, Germany), Niacinamide (Shandong Kunda Biotechnology, China), Stearyl Alcohol (KAO Corporation, Japan), Stearic Acid (IOI Acidchem, Malaysia), C14-22 Alcohols (Seppic, Germany), C12-20 Alkyl Glucoside (Seppic, Germany), Dimethicone (KCC, South Korea), Cetyl Ethylhexanoate (Berg+Schmidt, Taiwan), Ascorbyl Tetraisopalmitate (Nikko Chemical, Japan), Caprylyl Glycol (Activon, South Korea), Cyclopentasiloxane (Dow Chemical, USA), Cyclohexasiloxane (Dow Chemical, USA), and Ethylhexylglycerin (Schuelke & Mayr, Germany) were commercially obtained. All chemicals and solvents were of analytical grade or cosmetic grade.

Formulation of Lip Serum

The lip serum was formulated as an oil-in-water (O/W) emulsion. Three different formulations were prepared for the efficacy study.

Table 1. The formulation of lip serum

Active Ingredients (w/w %)	A	B	C
NAM	-	2	2
ATIP	3	-	3

To prepare the emulsion, Ascorbyl Tetraisopalmitate (ATIP) was first dispersed into the oil phase, which consisted of oil components Stearyl Alcohol, Stearic Acid, C14-22 Alcohols, C12-20 Alkyl Glucoside, Dimethicone, Cetyl Ethylhexanoate, Caprylyl Glycol, Cyclopentasiloxane, and Cyclohexasiloxane. Separately, Niacinamide was dissolved into the aqueous phase, which included water-soluble components Glycerin, Trisodium Ethylendiamine Disuccinate, PEG-5 Glyceryl Stearate, 1,2-Hexanediol, and Ethylhexylglycerin. The oil and water phases were then emulsified at a temperature of 60–65 °C for 10 minutes using high-shear mixing. This process ensured uniform dispersion of the active ingredients and stable emulsion formation.

The final product was a soft and hydrating gel-to-liquid cream, designed for comfortable application on the lips with a lightweight, non-greasy finish. All formulations were prepared under controlled laboratory conditions using cosmetic grade materials and stored in identical packaging to maintain consistency during the efficacy trial.

Subjects and Methods

A study was conducted to evaluate the lip brightening efficacy of three lip serum formulations over a period of 14 days. The study involved 15 healthy Indonesian women. The volunteers were aged from 19 to 41 years (Mean = 24.53; standard deviation = 5.51) including six women in the age range of 19-25, four women in the age range 26-30 and five women in the age range of 31-41. These volunteers were selected based on their bare lips color. Exclusion criteria were any surgical procedures and any tattooing of the lips. The volunteers were instructed not to apply any lip product prior to their appointment. The volunteers were divided into 3 groups, each group was assigned one of the three formulations and instructed to apply the product twice daily over a period of 14 days. The volunteers were advised to avoid using any other lip care or make up products during the study.

Instrumental Evaluation of Efficacy

In this study, Spectrophotometer CM-26d (KONICA MINOLTA) was used to measure L^* a^* b^* values of the lips. Where L^* value represents a gray scale with values from 0 (black) to 100 (white). The L^* value correlates with the level of pigmentation of an individual [11]. Other device such as Antera 3D was used to measured the Average Melanin Level, taken from the Hypoconcentration Pigmentation value. These measurements were conducted on T0 and T+14 days.

All measurements were conducted by trained evaluators under standardized environmental conditions. The data collected were statistically analyzed to determine the effectiveness of each formulation in improving lip brightness and reducing melanin levels.

3. Results

The efficacy evaluation of the lip serum formulations demonstrated noticeable improvements in both lip brightness and melanin reduction after 14 days of consistent application.

Lip Brightness (L^ Value)*

Changes in lip brightness were assessed by measuring the percentage increase in L^* value, which reflects the lightness of the lip skin. A higher L^* value corresponds to brighter lips.

Table 2. L* Value Result for Three Lip Serum Formulation

Formula	L* Value			
	T0	T+14	ΔL	%L Increase
A	57.62	58.12	0.50	0.86
B	59.58	60.16	0.58	0.97
C	58.28	59.43	1.15	1.98

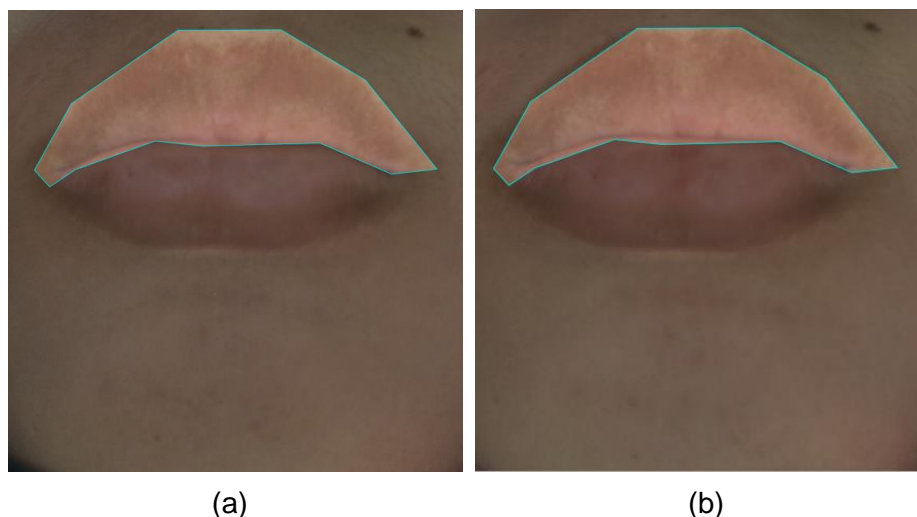
The formulation containing 2% niacinamide increase L* value by 0.97%, while the formulation with 3% ascorbyl tetraisopalmitate increase L* value by 0.86%. In addition, the combination of 2% niacinamide and 3% ascorbyl tetraisopalmitate resulted in the most significant increase in L* value by 1.98%, indicating a synergistic effect in improving lip brightness.

Melanin Reduction

Melanin content, which influences the visible darkness or pigmentation of the lips, was quantitatively evaluated using 3D imaging. A reduction in melanin level indicates effective depigmentation and a brighter lip appearance.

Table 3. Melanin Reduction Result for Three Lip Serum Formulation

Formula	Pigmentation Hypoconcentration			
	T0	T+14	Δ Hypoconcentration	% Effect
A	278.60	289.65	11.05	3.97
B	352.78	381.06	28.29	8.02
C	438.88	662.30	223.42	50.91

**Figure 1.** (a) Photo T0 of subject using 3% ATIP (b) Photo T+14 of subject using 3% ATIP

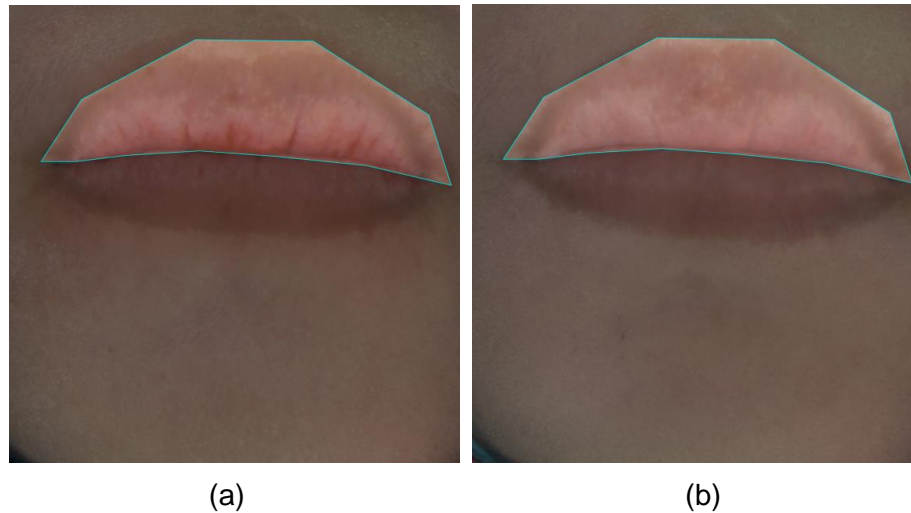


Figure 2. (a) Photo T0 of subject using 2% NAM (b) Photo T+14 of subject using 2% NAM

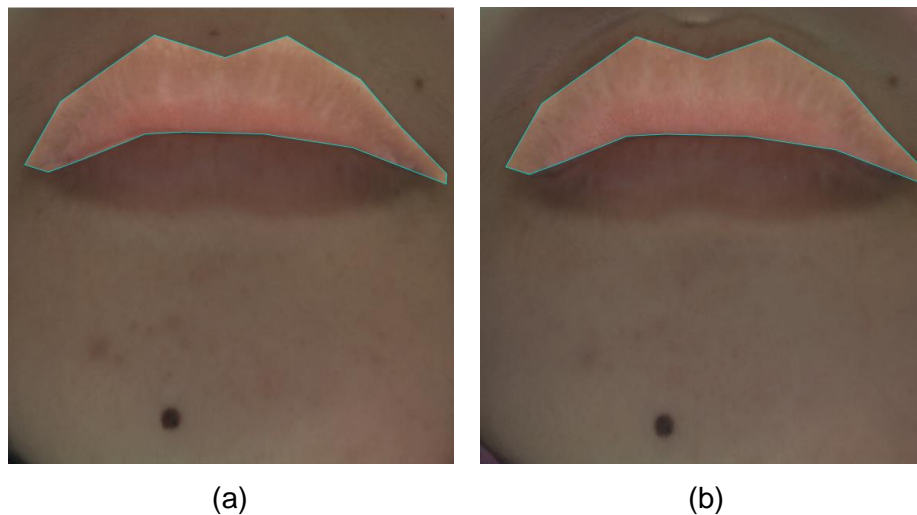


Figure 3. (a) Photo T0 of subject using 2% NAM + 3% ATIP (b) Photo T+14 of subject using 2% NAM + 3% ATIP

This significant result confirms that the combined actives work more effectively together than when used alone. The combination therapy appears to strongly suppress melanin deposition and support the visible brightening of lip skin over a short period.

4. Discussion

The present study utilized the L^* value and Hyperconcentration pigmentation parameter to quantitatively assess the evaluation on the lip brightness and pigmentation, with L^* value focusing on lightness and the hypoconcentration pigmentation parameter specifically targeting reductions in discoloration. The use of the L value* as an indicator of lightness is a standard and effective method for evaluating changes in the overall brightness of a color. With a scale ranging from 0 (black) to 100 (white), the L^* value allows for precise, objective measurement

of lightness, which is crucial for tracking subtle changes in lip color over time. In this study, the observed increase in L^* value in all three groups showed that the treatment effectively brightened the lips, making them appear lighter compared to baseline measurements. This method is particularly useful in providing a direct and quantifiable metric of brightness that is not influenced by subjective perception.

The addition of the hypopigmentation parameter further strengthens the analysis by specifically addressing pigmentation changes. Unlike the L^* value, which captures overall lightness, the hypopigmentation parameter is focused on the reduction of darker pigments and the uniformity of the lip color. The substantial difference observed between three groups in terms of hypopigmentation highlights the utility of this parameter in detecting more specific effects on lip coloration, beyond general lightness. By quantifying the extent of pigmentation reduction, the hypopigmentation parameter provides a clearer picture of how the treatment influences the appearance of dark spots or uneven pigmentation. Based on the result, L^* value and Melanin Levels (Hyperconcentration pigmentation) which were observed changes in these parameters following treatment with three different formulations need further investigations involving a larger sample size and an extended study duration to substantiate the efficacy of the lip brightening method and to validate the reliability of these parameters as assessment tools.

This study evaluated the efficacy of a lip serum formulated with niacinamide (NAM), ascorbyl tetraisopalmitate (ATIP), and their combination in enhancing lip brightness and reducing pigmentation. The results showed a significant increase in the %L and a marked reduction in melanin content after 14 days of application, indicating an effective improvement in overall lip appearance.

Both niacinamide and vitamin C are well-known active ingredients for skin-brightening purposes. In this study, the lip serum containing 2% NAM alone increased the %L value by 0.97% and reduced melanin levels by 8.02%. This is in line with previous studies that have shown niacinamide's ability to inhibit the transfer of melanosomes from melanocytes to keratinocytes, resulting in reduced pigmentation and improved skin tone [6]. Niacinamide also acts as an antioxidant, helping to mitigate oxidative stress that contributes to hyperpigmentation [7].

Similarly, the serum containing 3% ATIP demonstrated an increase in %L value by 0.86% and a melanin reduction of 3.97%. Ascorbyl tetraisopalmitate, a stable, oil-soluble vitamin C derivative, exhibits excellent skin penetration properties and is efficiently converted into active vitamin C (ascorbic acid) in the skin [8]. Vitamin C derivatives are known to inhibit tyrosinase activity, the key enzyme responsible for melanin synthesis, thereby contributing to skin-brightening effects [9].

In particular, the combination of 2% NAM and 3% ATIP demonstrated the highest effects, with an increase in %L value by 1.98% and 50.91% reduction in melanin levels. The outcome of the combination suggests a synergistic effect between niacinamide and ATIP. While niacinamide primarily inhibits melanosome transfer and strengthens the skin barrier, ATIP inhibits melanin synthesis and provides antioxidant protection, addressing pigmentation at multiple biological pathways. This synergism is consistent with prior findings in skin care where multi-target approaches have shown better outcomes compared to single-agent treatments [10].

The significant melanin reduction observed with the combination treatment is particularly worth for lip care were targeted on lip pigmentation. Since the lip area is characterized by a thinner

stratum corneum and greater vulnerability to environmental damage, active ingredients must be both effective and gentle.

Overall, the data support the hypothesis that niacinamide and ascorbyl tetraisopalmitate, both individually and in combination, are effective in improving lip brightness and reducing pigmentation. Future research could focus on investigating the long-term effects of continuous use, optimizing the concentrations for maximum efficacy, and expanding the study population. Furthermore, mechanistic studies investigating molecular changes in pigmentation-related pathways following topical application would provide deeper insights into the underlying biological actions of these active ingredients on the lips.

5. Conclusion

This study demonstrated that niacinamide (2%), ascorbyl tetraisopalmitate (3%), and their combination effectively improved lip brightness and reduced melanin levels after 14 days of use. The combination of niacinamide and ascorbyl tetraisopalmitate produced the most significant results, showing a synergistic effect in enhancing lip brightness and reducing pigmentation. These findings suggest that combining actives with complementary mechanisms of action can offer superior benefits compared to individual use. The development of targeted lip care products incorporating niacinamide and ascorbyl tetraisopalmitate holds great promise for addressing concerns related to lip hyperpigmentation. Future research with a larger and more diverse population, as well as longer evaluation periods, is recommended to further validate and expand on these results. Overall, this study contributes important insights into the advancement of lip care formulations, particularly in lip brightening products.

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