Cosmetic Efficacy Based on Cuticle Transparency"

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1. Introduction

Unlike the Western consumers who focus on whitening and depigmentation, many Asian consumers prefer a healthy and translucent complexion that emphasizes the beauty of smooth and bright skin. The transparency of the stratum corneum is not only a key physical basis for achieving a translucent skin appearance but is also closely related to the physiological health of the skin [1]. From a biological perspective, the transparency of healthy skin is significantly associated with the distribution of water in the stratum corneum, the distribution of melanin, and the optical properties of the skin surface [2]. Multiple skin color attributes affect the evaluation of semi-transparent skin. Among them, skin brightness and skin translucency have a positive impact, while the severity of tone, uneven skin tone, erythema, and pigmentation have a negative impact [3]. Therefore, research on the correlation between stratum corneum transparency and other physiological and optical indicators has become an important means to verify the skin's translucent appearance. By dynamically monitoring the changing trends of these variables and their correlation with the optical properties of the stratum corneum, the physiological basis of skin translucency can be revealed at the microscopic level, providing a scientific basis for the verification of skin care product efficacy, product development, and personalized skin care solutions.

With the increasingly strict ethical and regulatory restrictions on animal experiments, the demand for animal-free alternative testing technologies in the cosmetics industry is constantly growing. Although existing alternative methods (such as human reconstructed epidermis models and in vitro optical measurement techniques) have provided effective means for product safety assessment, their application in verifying skin transparency still has certain limitations. Currently, most alternative models mainly focus on irritation or toxicity endpoints and lack a systematic evaluation system for dynamic changes in skin aesthetic improvement.

Skin optical parameters (such as L*a*b* color space values, scattering coefficient, refractive index, and transmittance) are widely used to quantitatively reflect the physiological and optical state of the skin. The skin translucency tester TSL850 device emits a narrow beam of light from an LED source, which scatters within the object being measured. A part of the scattered light is collected by the detector, and changes in optical properties can accurately reflect changes in the skin's microstructure, making it an important proxy indicator for evaluating skin health and aesthetic attributes. Studies have shown that the self-perceived yellowing degree of Chinese women's skin is related to the measurement results of colorimeters and Mexameter, expert evaluations of periorbital pigmentation, and parameters of the skin pigmentation detector (CUBT) [4]. Building on the theoretical exploration and

practical verification achievements of predecessors, this study proposes a new animal-free efficacy evaluation system centered on stratum corneum transparency. By systematically exploring the dynamic correlation between skin transparency-related optical parameters and multiple efficacy indicators such as moisture retention, melanin, skin brightness value L, and skin tone uniformity, it aims to address the limitations of the existing efficacy verification system in evaluating translucency, further enhancing the scientific nature, standardization, and practical application value of efficacy testing methods, especially in response to the high attention paid to the aesthetic trend of healthy and translucent skin in the Asian market.

2. Materials and Methods

2.1. Subject recruitment and grouping

This study was approved by the Ethics Review committee and strictly adhered to the ethical guidelines of the Declaration of Helsinki. A total of 60 healthy Asian subjects who met the inclusion criteria were recruited through community announcements and within the company, aged 20 to 45 years (average 32.5±5.2 years), with skin types confirmed as type II-IV according to the Fitzpatrick classification criteria. Exclusion criteria included: pregnant or lactating women medical aesthetic interventions such as laser treatment or chemical skin renewal in the last 3 months diagnosis of chronic skin diseases such as eczema or psoriasis continuous use of functional skin care products containing retinoic acid, hydroquinone, etc. for the last 4 weeks history of smoking or systemic diseases. The subjects were double-blind divided into the moisturizing group (n=30) and the whitening group (n=30) by computer-generated block randomization, with stratified matching based on gender and initial skin chroma (L* value) to ensure balanced baseline characteristics between the groups.

2.2. Methods of study

Volunteers conducted all measurements in advance in a constant temperature and humidity laboratory (22±1 ° C, 50± 5%RH). The test area was uniformly 3×3 cm2 on the inner side of the forearm. Before the test began, the area to be tested was uniformly washed with soap base, and both arms were exposed for 30 minutes. The same laboratory technician performed the operation before and after.

60 volunteers were randomly divided into two groups: the moisturizing group and the whitening group; The moisturizing group applied 0.2g of 5% hyaluronic acid to the test area of the forearm, once in the morning and once in the evening. The whitening group used an intervention of 4% nicotinamide +2% arbutin, once in the morning and once in the evening, with 0.2g of the sample applied to the test area.

The moisturizing group collected data to assess the correlation between moisture and skin opacity; Data were collected in the whitening group to assess the correlation between melanin, L value, ITA value and skin opacity.

2.3 Device Information

Table1:Device Information

Dimensions	Measurement metrics	Parameter description	Instrument model	Measurement mode
Stratum corneum transparency	ALPHA value K value AREA value	The smaller the ALPHA value, the higher the skin transparency The higher the K value, the more	TSL850(Dia-Stron)	Three-point positioning scan

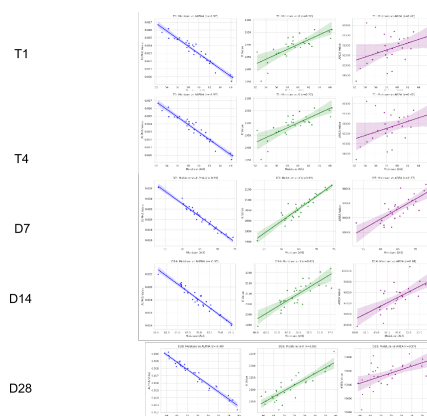| Dimensions	Measurement metrics	Parameter description	Instrument model	Measurement mode
		transparent the skin The larger the AREA value, the higher the skin transparency		
Moisturizing	Capacitance value (AU)	The higher the value, the more moisture the skin has	Corneometer CM825 (C+K)	Take the mean of three repeated measurements
Melanin	Melanin Index	The larger the Melanin Index, the darker the skin	Mexameter® MX18 (C+K)	Take the mean of three repeated measurements
Skin Colour	L* value ITA value	the larger the L value, the whiter the skin the larger the ITA value, the lighter the skin tone	Skin-Colorimeter CL 400 (C+K)	Take the mean of three repeated measurements

2.4 Data acquisition method

Baseline values: D0 (before sample intervention),Short-term effects with samples for 1 hour and 4 hours: T1 (1 hour after intervention), T4 (4 hours), Data from continuous use of samples for 7 days, 14 days, and 28 days: D7, D14, D28.

2.5 Statistical processing protocol

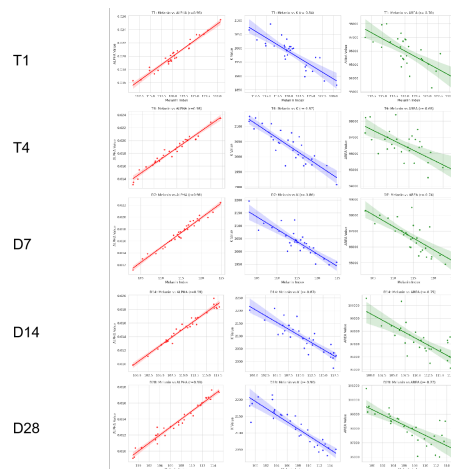Mixed-effects model analysis using SPSSAU 26.0:Correlation analysis: Pearson correlation analysis method

3. Results

By analyzing the measurement results of 30 volunteers in the moisturizing group at time points T1, T4, D7, D14, and D28, a significant correlation was found between Moisture AU and skin transparency indicators:
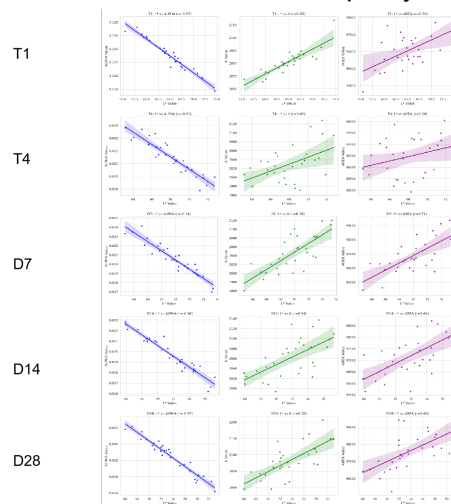

FIG 1: Correlation between moisture retention at T1/T4/D7/D14/D28 and skin opacity.
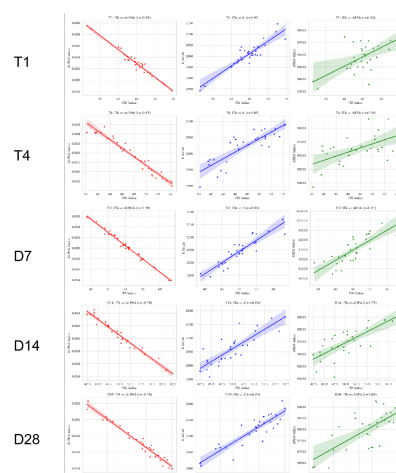
By analyzing the measurement results of 30 volunteers in the whitening group at time points T1, T4, D7, D14, and D28, it was found that Melanin, L value, ITA value were significantly correlated with skin transparency indicators:

FIG 2: Correlation between melanin and skin opacity at T1/T4/D7/D14/D28

FIG 3: Correlation between skin L values of T1/T4/D7/D14/D28 and skin opacity

FIG 4: Correlation between ITA values of T1/T4/D7/D14/D28 skin color and skin opacit

4. Discussion

The results of this experiment verified that the change in stratum corneum transparency can be used as an indicator to validate skin permeability and health, and to measure the ef-

fects of cosmetics on moisturizing, whitening and enhancing the skin's transparency. After 28 days of intervention, the skin moisture content, skin melanin, skin brightness L value and skin color ITA value were all significantly correlated with the parameters of skin transparency. The limitation lies in the sample size and observation period. In the future, it is necessary to expand the population and introduce multi-angle optical imaging and machine learning optimization analysis.

5. Conclusion

Collecting data from the moisturizing group, it was verified that skin transparency increased with the increase in skin moisture content; Moisture AU was moderately to strongly negatively correlated with ALPHA ($r = -0.71$ at D28), while moisture Au was significantly positively correlated with K and AREA ($r = 0.74$ and $r = 0.73$, respectively), indicating that as skin moisture content increased, Less scattering of light by the stratum corneum, thereby enhancing visual transparency of the skin.

By collecting data from the whitening group, it was verified that skin transparency decreased with increased Melanin in the skin, and Melanin Index was moderately positively correlated with ALPHA value ($r = 0.64$ to 0.70). The Melanin Index was negatively correlated with the K value and AREA value ($r = -0.68$ at D28), and the results showed that reducing melanin could enhance skin transparency; The skin brightness L value was significantly negatively correlated with the ALPHA value ($r = -0.60$ to -0.72), the L* value was positively correlated with the K value and AREA value, and the ITA value was negatively correlated with the ALPHA value ($r = -0.58$ to -0.75). ITA showed a significant positive correlation with both K and AREA values. Therefore, in the development and evaluation of skin care and beauty products, the combination of skin optical transparency indicators can provide a more comprehensive and objective method for assessing skin condition.

References:

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