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Application Status and Research Progress of Natural Pigments from Traditional Chinese Medicinal Herbs in Modern Lip Preparations

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Abstract: Herbal natural pigments represent a promising direction for modern cosmetic development. Typical medicinal plants such as Arnebia euchroma, Carthamus tinctorius and Curcuma longa possess diversified chromogenic components and biological activities, making them favorable colorants for lip preparations. This article reviews the sources, processing techniques and current applications of TCM pigments in lip cosmetics, and summarizes existing limitations including poor photothermal stability, unsatisfactory formula compatibility and incomplete quality evaluation systems. Future research will focus on green extraction, stabilization improvement and standardized quality control, aiming to provide technical references for the further development and industrial application of herbal pigments in modern lip products.

Keywords: Traditional Chinese medicine; Natural pigments; Herbal resources; Lip preparations; Lipsticks

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1. Introduction

Lip cosmetics can make your lips more beautiful, as well as provide beauty and skincare. Pigments are the main raw material, which determines the visual appearance, color effect, and practical performance of finished products. Furthermore, those naturally derived colors tend to get broken down and lose their color upon being subjected to heat, UV light, oxidative atmospheres, and pH changes during use [1].

Natural active substances attract much attention during the development of cosmetic raw materials. Such ingredients may help adjust color, offer antioxidant properties, moisturize skin and deliver other cosmetic benefits [2]. China is rich in traditional Chinese medicine resources. A large number of previous studies have confirmed that various TCM herbs and their extracts possess great potential to be developed into novel and safe modern cosmetic raw materials [3].

2. Sources and chromogenic components of TCM natural pigments

2.1. Basic characteristics and classification of TCM natural pigments

Major natural pigments from Chinese medicinal herbs originate from plant root, stem, leaf, flower, and fruit parts, and quinone, anthocyanin, flavonoid, and carotenoid form the main colored matter.

According to the overall hue, they can be divided into red-purplish red, yellow-orange yellow and other color systems. Compared with synthetic colorants with simple component structures, pigments extracted from natural medicinal herbs are mostly multi-component composite systems; their color performance is susceptible to the origin of raw materials, processing technologies and external environmental conditions [4]. Meanwhile, differences in the chemical structure of pigment parent molecules directly alter solubility properties (water-soluble/lipid-soluble), as well as their tolerance to pH, light, high temperature and other conditions, thereby affecting the dispersion stability and final color rendering of such pigments in oil-wax-based and liquid lip makeup substrates.

Therefore, when developing them as coloring materials for lip products, in addition to color rendering capacity, compositional controllability, stability and safety should also be investigated [5].

2.2. Red and purple TCM natural pigments

Arnebia euchroma can produce violet-red pigments. Its color is mainly derived from naphthoquinone compounds, including shikonin and its homologues [5]. A study by Lv et al. [6] demonstrated that roselle anthocyanins remain stable under acidic, low-temperature and dark conditions, while ultraviolet radiation and high temperature can significantly reduce their retention rate, indicating that light and heat stability should be prioritized in formula design for lip products. Carthamus tinctorius is a classic medicinal pigment material, and its main chromogenic constituent, safflower yellow pigment, belongs to chalcone compounds [5]. Rubia cordifolia is another traditional red pigment resource, with purpurin and mollugin as its key quality evaluation indicators; its active component contents vary with different extraction and processing techniques [7]. Current studies on these red and purple herbal pigments mainly focus on chemical composition analysis, extraction optimization and basic coloring properties. However, public research on their direct application in modern lip formulations is still insufficient, making them promising candidate colorants for further development.

2.3. Yellow and other TCM natural pigments

Turmeric and cape jasmine are common herbal sources of yellow pigments. Curcumin, the main pigment in turmeric, is a fat-soluble phenolic compound that presents yellow to orange-yellow hues [5]. Its lipophilic property facilitates compatibility with oil-phase systems, whereas its photo-thermal stability and color performance in lip preparations still require systematic evaluation. Gardenia yellow pigment is a water-soluble carotenoid mainly composed of crocin and crocetin, which possesses excellent coloring ability and has been relatively comprehensively studied in terms of extraction, purification and stability [8]. Given the differences in polarity, solubility and environmental stability among various herbal pigments, targeted dispersion and stabilization strategies should be selected according to different matrix characteristics when applying these pigments to lipsticks, lip balms and lip glosses. Meanwhile, color difference, color value and accelerated stability tests are required to evaluate their practical coloring performance scientifically.

3. Extraction, purification and stabilization of TCM natural pigments

Scientists select extraction techniques for plant natural pigments based on pigment polarity and the features of cosmetic substrates. Water and ethanol extraction methods are widely adopted for their simple operation. Oil maceration works better for oil-soluble pigments, which helps the pigments mix well with oil-wax lipid bases. Ye et al. [9] studied different extraction methods for gardenia yellow pigment and confirmed that ultrasonic extraction achieves higher color value and extraction efficiency. For lipophilic shikonin pigments from Arnebia euchroma, supercritical CO2 extraction was adopted, and a quantitative HPLC detection method was established to support efficient extraction and quality control [10].

Crude pigment extracts usually contain sugars, proteins and other impurities. These substances may interfere with color quality and the stability of cosmetic products. Therefore, refinement treatment is required to obtain qualified pigment samples in the study of Lycium ruthenicum anthocyanins, acidic ethanol extraction combined with macroporous resin purification effectively removed impurities and improved pigment purity, providing a feasible purification strategy for natural colorants [11].

Robustness is an obstacle that prevents the natural dyes from being widely adopted in lip-care preparations. Anthocyanins, on the other hand, are especially sensitive to pH variations as well as thermal and photochemical stressors and oxidation; all factors can speed up chromophore degradation [12]. Besides traditional control methods such as low-temperature and light-shielded processing, microencapsulation serves as an effective stabilization approach. By using gum arabic and β-cyclodextrin as wall materials, anthocyanin embedding efficiency reached 91.01%, significantly improving resistance against light and heat [11]. For different lip cosmetic systems, including solid lipsticks and liquid lip glosses, targetedextraction and stabilization strategies are required to ensure uniform dispersion, stable color performance, and satisfactory storage stability.

4. Application status of TCM natural pigments in modern lip preparations

Few academic studies have explored the direct application of natural pigments extracted from traditional Chinese medicinal herbs in modern lipstick formulations. Existing research mostly concentrates on conventional solid lipsticks and tinted lip balms, while systematic investigations targeting liquid lip gloss remain limited. Song et al. [13] prepared natural lipsticks using pitaya pigment and optimized the dosage of beeswax, coconut oil, cocoa butter and pigments. The optimized formulations exhibited good sensory performance, texture and color stability, confirming that the applicability of natural pigments depends on both pigment properties and oil- wax matrix ratios. Beeswax mainly maintains product shaping, while grease components improve pigment wetting, dispersion and spreadability, which makes matrix composition a core factor in lip formulation design.

Previous studies on plant-derived natural pigments showed that Monica's research team [14] prepared lipstick prototypes using ethanol mixed extracts of roselle and sappan wood. They modified the formulation by making changes to pH levels, melting points and hardness parameters. The study confirmed that these two plant pigments are suitable for lipstick preparation and proved that ingredient ratio greatly affects the finished product's color appearance and physical properties. As water-soluble colorants, anthocyanins usually show poor compatibility with oil-wax lipstick matrices. Setyawaty et al. [15] also found that purple sweet potato anthocyanin-based lipsticks possessed acceptable dispersion and molding properties but exhibited poor storage color stability. pH variation, temperature, light exposure and oxidation are key

limiting factors for the practical application of anthocyanins in lip cosmetics.

4. Conclusion

Pharmaceutical botanicals contain lots of natural hue-producing components, and they have great potential in terms of development. These may be regarded as the initial materials for colors used in modern lip care preparations. Although there has been research on pigment extraction and refinement, stability improvement, and cosmetics formulation testing, comprehensive studies focusing on direct application of TCM dyes in lip products remain inadequate.

Future research should focus on raw material standardization, pigment stabilization techniques, formula compatibility, safety assessment, and comprehensive quality control throughout production. In addition, standardized and verifiable evaluation systems should be formulated in line with industry specifications. Such improvements can support the industrial conversion of traditional Chinese medicine pigments from laboratory research to practical and market-applicable lip cosmetics.

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Disclosure statement

The authors declare no conflict of interest.

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