

# Natural lip tint formulation using beetroot (*Beta vulgaris*) and strawberry extracts (*Fragaria vesca*) for safe cosmetic use

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**Abstract.** Naziihah S, Ainurofiq A. 2026. Natural lip tint formulation using beetroot (*Beta vulgaris*) and strawberry extracts (*Fragaria vesca*) for safe cosmetic use. *Asian J Nat Prod Biochem* 24 (1): f240103. <https://doi.org/10.13057/biofar/f240103>. Public awareness of the harmful effects of synthetic ingredients, especially in lip products, has driven demand for safe and natural cosmetics. The Indonesian Food and Drug Authority has found many unauthorized cosmetic products containing hazardous substances, such as mercury and rhodamine B, which are banned. Natural pigments from red beet and strawberry offer a promising alternative. These fruits contain betanin and anthocyanin, respectively, which are natural colorants. They also have strong antioxidant properties that can benefit lip health and protect against environmental stressors. This study evaluates lip tint products with varying ratios of beet and strawberry extracts. Formulated three variations of extract concentration; the tests included organoleptic observations, homogeneity, pH, spreadability, irritation, panelist preference, and anthocyanin levels and stability analysis for three weeks. Formula F2 (50% Beetroot, 10% Strawberry) exhibited the highest anthocyanin content (22.634 mg/L) among the formulations. Additionally, its pH of 4.49 closely aligns with the physiological range of the lips (4.5-6.5). Notably, all formulations met the adhesive strength standard (>1 second) and demonstrated satisfactory homogeneity. The novelty of this research lies in the synergistic combination of beet and strawberry extracts as natural dyes. Beets provide a robust, stable purplish-red pigment, while strawberries contribute brightness and antioxidant benefits. This combination offers a safe, stable, and aesthetically pleasing alternative to hazardous synthetic dyes. Two of the three formulas maintained a pH within the physiological range (4.5-6.5), while one deviated slightly below the standard. Notably, the entire formulation exhibits stable homogeneity and does not cause skin irritation. The panel test revealed that the majority of respondents favored the product's color, aroma, and texture. In summary, the combination of red beet and strawberry extracts demonstrates significant potential as a natural, safe, and consumer-friendly alternative to synthetic dyes in lip tint formulations.

**Keywords:** Beetroot, characterization, lip tint, natural colorant, strawberry

## INTRODUCTION

Over the past decade, the global cosmetic industry has undergone a significant transformation in consumer behavior. There is a growing demand for "clean beauty" products, which are not only effective but also free from potentially harmful synthetic chemicals (Amberg and Fogarassy 2019). Cosmetics applied to the lips, such as lipsticks, lip balms, and lip tints, occupy a unique position in this market due to their application to a highly permeable mucous membrane and the potential for inadvertent ingestion. Studies indicate that regular users of lip products may ingest several pounds of the product over their lifetime. This reality has raised substantial concerns regarding the safety of synthetic dyes, preservatives, and heavy metal contaminants commonly found in commercial lip formulations (Al-Saleh et al. 2009). Lip cosmetics serve both aesthetic and protective functions. The skin of the lips is significantly different from the skin on the rest of the body; it lacks a thick stratum corneum, sweat glands, and sebaceous glands (Barel et al. 2014). This makes the lips highly susceptible to dehydration, UV damage, and chemical irritation. Consequently, the ingredients in lip

products must be carefully selected to ensure they provide a protective barrier while delivering color. The trend toward natural ingredients is not merely a marketing strategy but a response to the toxicological profiles of synthetic alternatives (Panico et al. 2019).

The global consumer demand for safe, natural cosmetics is driven by significant concerns regarding the contamination of lip tint products with hazardous substances. The Indonesian Food and Drug Monitoring Agency (BPOM) has identified and recalled numerous cosmetic products, including lip tints, that contain prohibited substances such as mercury and rhodamine B. The use of these substances is strictly prohibited under Regulation of the Director General of BPOM of the Republic of Indonesia Number 18 of 2015 (Badan Pengawas Obat dan Makanan (BPOM) 2024). This discovery necessitates the immediate development of effective lip tint formulations that guarantee safety.

Synthetic lip colorants, mainly azo dyes (e.g., Red 7 Lake, FD&C Yellow 5), petroleum-derived waxes, and parabens, dominate commercial formulations (Pereira and Chang 2018). While effective for vibrancy and stability, these compounds pose health risks. Azo dyes may degrade

into aromatic amines, potential carcinogens (International Agency for Research on Cancer (IARC) 2017). Parabens, used as preservatives, mimic estrogen and accumulate in tissues, as shown in breast cancer biopsies (Rastogi and Johansen 2010). Heavy metals like lead and chromium exceed safe limits in up to 20% of tested lip products (Hepp 2018). Synthetic antioxidants like butylated hydroxytoluene (BHT) paradoxically induce oxidative stress, causing lip dryness and premature aging (Nath 2017). Lip tints, requiring repeated application and prolonged mucosal contact, increase bioavailability (Pereira and Chang 2018). Regulatory bodies worldwide, including the European Union's Cosmetics Regulation (EC) No 1223/2009, enforce stringent limits on such ingredients, mandating irritation, sensitization, and microbial safety testing (European Commission 2009). Non-compliance persists, fueling demand for biocompatible alternatives.

The utilization of natural pigments derived from plants presents a promising solution. Red beets (*Beta vulgaris*) and strawberries (*Fragaria vesca*) have been identified as superior natural resources. Red beets are rich in betanin, a Betalain pigment that imparts a purplish red hue, while strawberries are abundant in Anthocyanins, which generate vibrant red pigments (Briane 2018). Chemically, Betalain (Betasianin) exhibits superior stability against oxidation compared to other pigments. Combined with Anthocyanins (whose stability is pH-sensitive), this combination is anticipated to produce a more intense, stable purplish red color from an aesthetic perspective. Beyond coloring, this combination offers functional advantages: Betaine from beets acts as a potent humectant. At the same time, ellagic acid in strawberries serves as an antioxidant, providing an added value for lip health that synthetic dyes lack.

Beetroot is rich in betalains, which are classified into two main subclasses: betacyanins and betaxanthins. Betacyanins exhibit a red-purple color and predominantly consist of betanin and betanidin 5-O- $\beta$ -glucoside. In contrast, betaxanthins are yellowish-orange. While betacyanins generally exhibit greater stability against oxidation and heat than betaxanthins, vulgaxanthin I (a betaxanthin) demonstrate significantly greater lability under specific thermal treatments and acidic conditions (Manchali et al. 2013). Strawberries are rich in anthocyanins, primarily glycosylated derivatives of pelargonidin and cyanidin, which impart their characteristic red color. The color and stability of anthocyanins in strawberries are significantly influenced by pH and structural factors, such as acylation and co-pigmentation interactions (Khan 2016; Jurić et al. 2020).

Among lip cosmetics, lip tints have gained significant popularity, particularly influenced by East Asian beauty trends (Kim and Lee 2018). Unlike traditional lipsticks that rely on heavy waxes and high-coverage pigments, lip tints are typically water or oil-based formulations that "stain" the lips for a more natural appearance (Barel et al. 2014). They provide a lightweight feel and long-lasting wear without the greasiness associated with traditional sticks. However, most commercial lip tints still rely on synthetic stains that can be difficult to remove and may dry out the lips (Amberg and Fogarassy 2019). Developing a 100%

natural lip tint requires a sophisticated understanding of how plant extracts interact with natural humectants such as glycerin and thickeners like xanthan gum to achieve the desired viscosity and staining power (Rowe et al. 2009).

This novel research investigates the utilization of a synergistic combination of beetroot and strawberry extracts as natural colorants in lip tint formulations to achieve a more intense, stable, and aesthetically pleasing purplish-red color. By leveraging the unique properties of betanin and anthocyanin pigments, this approach enhances the color vibrancy and stability. Additionally, the incorporation of antioxidant and moisturizing properties further enhances the lip tint's overall quality (Ainurofiq et al. 2023). While the potential of natural colorants has been extensively studied, comprehensive research exploring the combined use of beetroot and strawberry extracts in lip tint formulations, encompassing their physical properties and stability, remains relatively limited. This approach presents a safe alternative to synthetic colorants and is underutilized in lip cosmetic product development.

In the product development process, testing physical properties is paramount to ensuring the formulation's quality. The physical characteristics of lip tints can be assessed through various methods, including organoleptic evaluations, homogeneity checks, pH measurements, spreadability tests, irritation potential tests, and consumer preference assessments.

By leveraging the chromophoric and therapeutic synergy of beetroot and strawberry, this research pioneers a safe, stable, multifunctional lip tint. This innovation bridges traditional wisdom with modern cosmeceutical science. It contributes to clean beauty paradigms, offering a blueprint for eco-friendly cosmetics compliant with global standards. This approach has the potential to reduce synthetic exposure risks while empowering the valorization of natural ingredients.

## MATERIALS AND METHODS

### Materials

The primary ingredients utilized in this lip tint formulation include red beetroot extract (*B. vulgaris*), strawberry extract (*F. vesca*), castor oil, glycerin, phenoxyethanol, ascorbic acid, tatty fruity flavor, pH paper, methanol, acetic acid, 2N HCl, and distilled water.

The red beets and strawberries were collected from a plantation in the Tawangmangu region. To verify the authenticity of the ingredients, plant identification was conducted in the Biology Laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret (UNS), Central Java, Indonesia. The identification results confirmed the identification of the plants studied: red beets (*B. vulgaris*) and strawberries (*F. vesca*). The extract preparation process involved separating the sorted, washed, and chopped fruit. Juice extraction was performed using a masticating juicer (slow juicer) to produce pure fruit extract.

In determining anthocyanin levels using the differential pH method with UV-Vis spectrophotometry, the reagents

included a pH 1.0 buffer solution (KCl and HCl), a pH 4.5 buffer solution (sodium acetate and HCl), and methanol as the diluent.

The preparation of volunteers for the irritation test received administrative approval, specifically Ethical Clearance (EC), from the Health Research Ethics Committee of Dr. Moewardi Regional Hospital, Indonesia.

### Preparation

Administrative approval and ethical clearance were obtained from the Health Research Ethics Committee at Dr. Moewardi General Hospital, which are essential for validating the feasibility and safety of testing on human subjects. Subsequently, volunteer recruitment and preparation were executed. Interested volunteers were required to sign an informed consent form as a formal acknowledgment of their participation. This study employed an experimental design, formulating three lip tint variations (F1, F2, F3). The total concentration of Red Beetroot (RB) and strawberry (S) extracts was maintained constant at 60% of the preparation volume. The formula variations were determined based on the RB:S ratio: F1 (45%:15%), F2 (50%:10%), and F3 (55%:5%). All quantitative physical tests, including pH, adhesion, and spreadability tests, were conducted in triplicate (three replicates) to ensure data reliability. The pH was measured with a pH meter to ensure that the preparation was within the physiological range of lip skin (4.0 to 6.5). The Irritation Potential Test was conducted using the Open Patch Test method on the inner forearms of 15 panelists. The product was applied and observed for 15 minutes to prevent potential adverse reactions before use on the lips. Panelist inclusion criteria included being between the ages of 18 and 30, possessing normal skin, and having no history of allergies.

### Extraction

The extraction process for pure red beetroot and strawberry was carried out using a masticating juicer, also known as a slow juicer, to optimize the yield of concentrated extracts while minimizing pigment degradation. The extract is a pure juice, free of pulp. The anthocyanin content is qualitatively assessed using a 2N HCl and heating to assess the stability of the red color. Quantitative determination of anthocyanins is achieved using a pH-differential method with UV-Vis Spectrophotometry, using buffer solutions at pH 1.0 and 4.5.

### Qualitative anthocyanin test

It was achieved by heating the extract in 2N HCl for approximately five minutes at 100°C.

### Determination of anthocyanin content

The anthocyanin content was determined by preparing two buffer solutions: at pH 1.0 (KCl + HCl) and pH 4.5 (sodium acetate + HCl), as outlined in the method (Herlina et al. 2023). A 0.5 mL extract was diluted in 5 mL of methanol, and 1 mL of this diluted solution was further diluted to 10 mL. The absorbance of the sample at pH 1.0

and 4.5 was measured using a UV-Vis spectrophotometer to calculate the anthocyanin content. The anthocyanin content can be calculated using the following formula:

$$\text{Anthocyanin Content (mg/L)} = \frac{A \times MW \times FP \times 1000}{\epsilon \times l}$$

Absorbance = (A510 - A700) pH 1.0 - (A510 nm - A700 nm) pH 4.5

Where:

A: Absorbance

ε: Molar absorptivity of cyanidin-3-glucoside, which is 26900 L/(mol.cm)

L: Cuvette width = 1 cm

MW: Molecular weight of cyanidin-3-glucoside (449.2 g/mol)

FP: Dilution Factor

The differential pH method is used in conjunction with a UV-Vis spectrophotometer to determine anthocyanin content. The standard method for measuring Total Monomeric Anthocyanin (TMA) involves mitigating the effects of interfering substances. The determination of TMA levels requires the preparation and validation of a standard curve using Cyanidin-3-Glucoside or other equivalent standards. The maximum wavelength is measured before preparing the standard curve. The sample is then dissolved in pH 1.0 and pH 4.5 solutions, and the absorbance is measured at the wavelengths obtained during the previous measurement: 512 nm and 700 nm for pH 1.0, and 516 and 700 nm for pH 4.5. The 512 nm wavelength is preferred because it closely matches the 510 nm wavelength of cyanidin-3-glucoside. Cyanidin-3-glucoside is commonly used as a reference compound for anthocyanin (Herlina et al. 2023). The 700 nm wavelength is utilized to correct for any remaining sediment or impurities present in the sample. In the absence of any impurities, the absorbance at 700 nm will be zero (Lestari and Hamzah 2022). In addition to the TMA measurement, other tests such as organoleptic evaluation, homogeneity assessment, patch testing, and panelist preference evaluation are conducted to assess product quality and safety.

### Lip tint preparation

The lip tint was formulated in three variations of extract concentration (Table 1). The dye was dissolved in the castor oil as a color dispersion medium. Phenoxyethanol was incorporated as a preservative, while ascorbic acid served as an antioxidant.

Castor oil was mixed with red beet and strawberry extracts in accordance with the specified formula (solution 1). Simultaneously, ascorbic acid was dissolved in glycerin (solution 2). The two solutions were merged and homogenized, then combined with phenoxyethanol and Tutti Frutti fragrance, and placed in packaging containers.

The formula (Table 1) was modified based on Haq's (2021) study. The quantity of additives (excipients) is specified in the Handbook of Pharmaceutical Excipients, which recommends 30% glycerin and 0.5-1% phenoxyethanol (Rowe et al. 2009).

### Evaluation of the physicochemical properties of lip tint

#### *Organoleptic test*

Organoleptic evaluation of lip tint preparations assesses the quality of the ingredients and the consistency of the formulation, including the color, aroma, shape, and texture. This evaluation is conducted visually and through direct observation.

#### *Homogeneity test*

The purpose of the homogeneity test is to ascertain that the lip tint components are thoroughly mixed and evenly distributed. Homogeneity is verified by applying the preparation to a transparent glass slide and visually observing a uniform appearance, free of coarse grains or phase separation (Ainurofiq et al. 2025).

#### *pH test*

The pH test is used to determine whether the lip tint preparation falls within the physiological pH range of the lips, 4.0-6.5. This assessment is conducted by applying the preparation to pH paper and observing the color change to determine the acidity level. Before use, the pH meter must be calibrated to ensure precise results. The testing procedure involves alternately dipping the electrode into each sample.

#### *Stain test*

The stain test is a visual examination that assesses the color that adheres to the back of the hand after application (Nasution et al. 2022). This test is conducted visually by applying lip tint to the arm and subsequently observing the quantity of color that adheres after four applications. If the color release appears faint, it is suboptimal. Conversely, if the color release is clear and even, it indicates good color retention of the lip tint.

#### *Irritation test*

It assesses the potential for adverse skin reactions associated with the product. An open patch test was conducted on the inner forearms of 15 panelists, with the patches applied for 15 minutes. The preparation was applied to a 2.5×2.5 cm area of the skin, which was left open to observe the skin's response. Evaluation was conducted at multiple time points to distinguish transient responses from potential permanent irritation. Specifically, time point 1 (15 minutes) was used to record initial observations after the preparation was applied. Time point 2 (1 hour) was used to observe the skin reaction further and confirm its stability. The observation parameters included erythema (redness), pruritus (itching), and edema (swelling) (positive result). Safety results for all formulations were negative, indicating that the product is safe and does not cause skin irritation (Puspita et al. 2025).

Inclusion criteria for volunteers (Usha et al. 2025): (i) Men and women aged 18 to 30 years, (ii) Individuals with normal skin and no history of allergies, (iii) Those who can provide informed consent to participate in the study.

Exclusion criteria for volunteers (Yanasan et al. 2024): (i) Individuals with a history of skin disease, such as eczema, within the past few months before the study, (ii)

Individuals with scars or tattoos on the skin area to be tested, (iii) Individuals currently using prescription skincare products.

#### *Preference test*

A visual preference test was conducted using 15 panelists. Each panelist applied each lip tint formulation directly to their lips and subsequently rated each formulation variant based on three levels of preference: color, aroma, and texture. Each questionnaire response was assigned an assessment score ranging from 1 to 12. The questionnaire score was interpreted as follows: 1-3 = Don't like it; 4-6 = Don't really like it; 7-9 = Like it; and 10-12 = Love it. These ratings were recorded through a questionnaire (Harahap et al. 2025). The assessment results were subsequently converted to percentages to determine the level of preference.

#### *Adhesion test*

An adhesion test was conducted by positioning a lip tint sample between two slides. One side of the slide is secured with a string attached to a 50-gram weight (Lowra et al. 2024). The other slide is then placed over the preparation. The duration to separate the two slides is an indicator of the product's adhesive strength. The minimum standard for satisfactory adhesion is >1 second.

#### *Spreadability test*

A spreadability test was conducted to assess the distribution of lip tint upon application. The product was placed between two glass spheres, each containing 150 grams, and left undisturbed for one minute. The spreadable diameter was subsequently measured in centimeters. A spreadability value was considered satisfactory if it fell within the range of 5 to 7 centimeters.

#### *Stability test*

Stability testing is the systematic evaluation of a preparation's shelf life. It involves repeated observations (once weekly for 3 weeks) to assess potential changes in color, aroma, texture, homogeneity, and pH (Asyifaa et al. 2017).

#### **Data analysis**

Descriptive data analysis was conducted for qualitative data, including organoleptic characteristics (color and aroma) and homogeneity. Physical stability (pH test) was assessed by pH meter repeated testing over three weeks (once a week), with each test conducted three times, and the average was calculated (Arnandea 2020).

Quantitative data were analyzed using One-Way Analysis of Variance (ANOVA). Before applying ANOVA, a Test for Homogeneity of Variance (Levene's Test) was performed.

The ANOVA test was valid, as the assumption of homogeneity of variance was met ( $p > 0.05$ ) for the pH and spreadability tests (Table 2). Significant ANOVA results ( $p < 0.05$ ) prompted the use of a Post-Hoc Test (Bonferroni) to identify specific differences between formulas.

**Table 1.** Lip tint preparation formula

Ingredients	Formula			Function	Source
	F1(%)	F2 (%)	F3 (%)		
Beetroot extract	45	50	55	Coloring	Harefa (2019)
Strawberry extract	15	10	5	Coloring	Dewi and Astriana (2019)
Castor oil	18.5	18.5	18.5	Color dispersant	Rowe et al. (2009)
Glycerin	20	20	20	Humectant	Rowe et al. (2009)
Phenoxyethanol	1	1	1	Preservative	Rowe et al. (2009)
Ascorbic acid	0.1	0.1	0.1	Antioxidant	Rowe et al. (2009)
Tutty fruity flavour	0.1	0.1	0.1	Flavoring	Harefa (2019)

**Table 2.** Results of quantitative statistical analysis

Test parameters	Levene's test (Homogeneity)	One-Way ANOVA test (Significant Difference)	Post Hoc test	Information
pH	Significance value $p > 0.05$ ( $H_0$ is accepted)	Significance value $p = 0.000$ ( $p < 0.05$ )	Bonferroni	There is a significant relationship between formulation and pH
Adhesion	Not tested	Significance value $p = 0.000$ ( $p < 0.05$ )	Bonferroni	There are significant differences between the three formulations (F1, F2, F3) in adhesion parameters
Spreadability	Significance value $p > 0.05$ (Homogeneous variance)	Significance value $p = 0.006$ ( $p < 0.05$ )	Post Hoc	There were significant differences among formulation groups (F1 differed significantly from F2 and F3)

## RESULTS AND DISCUSSION

The formulation used in this study yields a distinct color in each lip tint. Subsequently, color changes were observed in the sample. The results of the anthocyanin test are presented in Table 3.

Table 3 showed that the extracts of beetroot and strawberries contain anthocyanins. There is no color change when these extracts are reacted with 2N HCl. The addition of HCl, coupled with heating, results in the formation of acidic compounds (Figure 1).

The anthocyanin content in beetroot and strawberry extracts was determined using the differential pH method with visible spectrophotometry. The average content results of three replicates of anthocyanin in pH treatments on beet extract, strawberry extract, pure extract, F1, F2, and F3 were respectively 18,968, 71,985, 35,712, 10,456, 22,634, and 20.05 mg/L. The absorbance at pH 1.0 and 4.5 at various wavelengths, along with the anthocyanin content, is presented in Table 4.

The correlation between absorbance and anthocyanin content was evident; higher absorbance corresponded to higher anthocyanin content. The anthocyanin content of the beetroot and strawberry combinations differs. Pure strawberries contain 71,985 mg/L, while F1, F2, and F3 contain 10,456, 22,634, and 20,050 mg/L, respectively. (Table 5).

The next step involves formulating lip tint at the prescribed concentration and subsequently conducting tests to evaluate its characteristics.

### Organoleptic test

Visual assessments were conducted to evaluate the color, form, odor, and texture of the formulations. There

was a color difference in F1 and F2, with red and pink purple in F3. Meanwhile, the form, odor, and texture were relatively similar for all formulas: liquid, tutty fruity, and soft. The outcomes of the organoleptic test are presented in Table 6.

### Homogeneity test

In principle, the homogeneity test shows that all formulas are homogeneous and there are no coarse grains. The outcomes of the physical evaluation of homogeneity are presented in Table 7.

### pH test

pH analysis assesses the acidity or alkalinity of lip tint preparations. This testing is crucial as improper pH levels can cause irritation and discomfort of the lips. The average pH results from three tests on three formulas produced F1 4.27, F2 4.49, and F3 4.78. Table 8 presents the pH results for lip tint formulas.

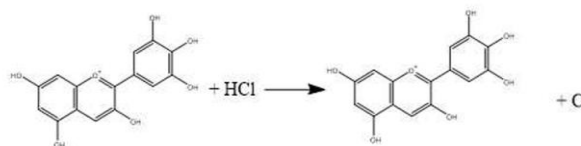
### Stain test

F1 achieved good stain test. F2 achieved good stain test, and F3 achieved good stain test and thickness. The results of the stain test for each formula were presented in Figure 2.

Visual description of color (stain test), shows that F1 red with a slight hint of purple, F2 red with a mix of purple evenly, and F3 deep purple color. Table 9 presents a comparative analysis of visual color intensity (derived from stain test results) and anthocyanin content of each lip tint formulation.

**Table 3.** Anthocyanin content in beetroot and strawberry extracts

Sampe	Identification	Results	Explanation
Beetroot extract	Extract + HCL 2N, heated for 2 minutes	Red color does not fade	+
Strawberry extract	Extract + HCL 2N, heated for 2 minutes	Red color does not fade	+

**Figure 1.** Anthocyanin reaction with hydrochloric acid**Table 4.** The anthocyanin content of extracts and formulations was at pH 1.0 and 4.5

Sample	Absorbance pH 1.0 (512nm; 700nm)	Absorbance pH 4.5 (516nm; 700nm)	Anthocyanin content (mg/L)	Average (mg/L)	SD	CV%
Beet Extract	2.234; 0.074	2.115; 0.070	19.227	18.968	0.024	0.01%
	2.229; 0.076	2.111; 0.071	18.839			
	2.228; 0.076	2.110; 0.071	18.839			
Strawberry Extract	0.536; 0.014	0.103; 0.012	71.985	71.985	0	0%
	0.536; 0.014	0.103; 0.012	71.985			
	0.536; 0.014	0.103; 0.012	71.985			
Extract Mixture	1.603; 0.066	1.507; 0.179	34.935	35.712	0.693	0.02%
	1.598; 0.066	1.499; 0.184	36.267			
	1.598; 0.065	1.503; 0.185	35.933			
Formula 1 (F1)	3.087; 0.068	3.057; 0.094	9.351	10.456	1.399	0.13%
	3.085; 0.068	3.053; 0.095	9.987			
	3.095; 0.068	3.050; 0.095	12.029			
Formula 2 (F2)	2.484; 0.092	2.301; 0.043	22.364	22.634	0.649	0.03%
	2.477; 0.087	2.301; 0.044	22.164			
	2.481; 0.087	2.297; 0.043	23.374			
Formula 3 (F3)	2.225; 0.195	2.087; 0.178	20.217	20.05	0.289	0.01%
	2.224; 0.196	2.085; 0.175	19.717			
	2.226; 0.195	2.084; 0.174	20.217			

**Table 5.** Anthocyanin content in the lip tint formula

Sample categories	Beet root extract (%)	Strawberry extract (%)	Average anthocyanin content (mg/L)	Anthocyanin content information
Pure strawberry extract	0%	100%	71.985	The highest level of all samples
F1	45%	15%	10.456	The lowest level among the formulas
F2	50%	10%	22.634	The highest level among the formulas
F3	55%	5%	20.05	Intermediate levels between F1 and F2

**Table 6.** Organoleptic analysis of lip tint formulations

Organoleptic test	Result		
	Formula 1	Formula 2	Formula 3
Color	Red	Red	Pink Purple
Form	Liquid	Liquid	Liquid
Odor	Tutty Fruity	Tutty Fruity	Tutty Fruity
Texture	Soft	Soft	Soft

**Table 7.** Homogeneity analysis of lip tint formulations

Formula	Visual observation (Glass Smear)	Microscopic (40× Magnification)	Stability (Week 3)
F1	Homogeneous (+)	No coarse grains	Remain Homogeneous
F2	Homogeneous (+)	No coarse grains	Remain Homogeneous
F3	Homogeneous (+)	No coarse grains	Remain Homogeneous

**Table 8.** pH of lip tint preparations

Formula	Beet concentrate	Strawberry concentrate	Average pH	SD	CV%
F1	45%	15%	4.27	0.005	0.110
F2	50%	10%	4.49	0.005	0.105
F3	55%	5%	4.78	0.008	0.171

**Table 9.** Visual color intensity of lip tint formula

Formula	Composition (Beetroot: Strawberry)	Visual description of color (stain test)	Color intensity	Average anthocyanin content (mg/L)
F1	45%:15%	Red with a slight hint of purple	Currently	10.456
F2	50%:10%	Red with a mix of purple evenly	Strong/Even	22.634
F3	55%:5%	Deep purple color	Very Thick	20.05

**Figure 2.** Stain test: A. F1, B. F2, C. F3

### Irritation test

The panelists' tests yielded negative results for irritation, indicating that the lip tint did not cause any irritation such as itching, redness, or swelling. The irritation test in Figure 3 indicates that the beetroot and strawberry extract lip tint is safe to use as it does not cause any irritation.

### Preference test

A sensory preference test was conducted to assess the panelists' acceptance of the lip tint preparations. In terms of panelists' preferences for the three formulas, they were quite varied. Based on the love its category, F1, F2, and F3, the number of panelists was 8, 4, and 9, respectively. Meanwhile, the like it category, F1, F2, and F3, had 7, 10, and 3 panelists, respectively. The don't really like it category, F1, F2, and F3, had 0, 1, and 3 panelists, respectively. There were also no panelists in the don't like it category. The results of the preference test were presented in Table 10.

Table 10 indicates that formula F1 received the majority of "Love it" ratings, while the remaining panelists opted for "Like it" ratings. Conversely, formula F2 had "Like it" ratings from the majority of the panelists. Formula F3 predominantly had "Love it" ratings, with only three panelists indicating a "Don't really like it" rating. The variations in color, texture, and aroma observed among the preparations did not significantly affect the panelists' overall preferences. The Tutty Fruity aroma consistently delivers a positive impact across all formulas, enhancing sensory appeal. Overall, all three formulas demonstrated favorable consumer acceptance based on the sensory parameters evaluated.

### Adhesion test

The adhesive test for the three formulas from the average results of 3 replications, respectively F1, F2, F3, is as follows: 1.79, 1.54, 1.64 seconds. The data in Table 11 exhibited a Coefficient of Variation (CV) below 10%, indicating high homogeneity and reliability. Levene's Test yielded a p-value greater than 0.05, indicating that the data were homogeneous and suitable for further analysis. The results indicated significant differences in adhesion between the formulations.

### Spreadability test

The diameter of the resulting spread is measured in centimeters. The spreadability test results for F1, F2, F3 averaged three replications respectively 6.17, 7.07, and 7.37 cm. Table 12 presents the outcomes of the spreadability test. The results indicate that the F1 formulation differed significantly from F2 and F3 ( $p < 0.05$ ), whereas F2 and F3 did not differ significantly. These findings suggest that the characteristics of formulation F1 differ substantially from those of the other two formulations.

### Stability test

In principle, the results of the organoleptic stability test for three weeks showed that the odor remained consistent with the tutty fruity, while the homogeneity remained unchanged for three weeks. The color also changed slightly each week, becoming faded. Descriptive data analysis was conducted for organoleptic data, including color, odor, and homogeneity, as presented in Table 13.

All formulas exhibited color changes while maintaining consistent homogeneity and a consistent Tutty Fruity aroma. During the initial week, all formulas (F1, F2, and F3) showed a striking red or purplish pink color, indicating

(+) homogeneity. The following week, the colors of formulas F1 and F2 gradually faded, while formula F3 retained its slightly faded purplish-pink hue. In the final week, all formulas exhibited a more pronounced color fading, with F1 and F2 transitioning to a more muted red, and F3 becoming a more faded pink. Despite a decrease in color intensity, all three formulas maintained good homogeneity throughout the observation period. Table 14 presents the pH of the formulas.

As shown in Table 14, all lip tint formulations in the third week exhibited stable pH values. Formula F1 had an average pH of 4.27, which fell below the ideal pH range (4.5-6.5) (Mulyawan and Suriana 2013). Formula F2 had an average pH of 4.50, which was at the lower limit of the ideal pH range. Formula F3 had an average pH of 4.78, within the acceptable range.

Based on the findings of this study, the lip tint formula, derived from extracts of red beet (*B. vulgaris*) and strawberry (*F. vesca*), produces a stable preparation that adheres to cosmetic quality standards as a natural dye, replacing synthetic alternatives. Quantitatively, the developed formula exhibits a measurable anthocyanin content, indicating the successful integration of natural pigments into the preparation. The pH of the formulas is within the physiological pH range of the lip skin, making them safe (non-irritating). The formulas also exhibit excellent adhesion and ease of application, acceptable to consumers based on color, aroma, and texture. This preparation not only ensures safety and stability but also demonstrates aesthetic and functional qualities as an alternative to natural lip color.

## Discussion

The anthocyanin content in beetroot and strawberry extracts served as the natural dye. Anthocyanin, a compound belonging to the flavonoid group, functions as a natural dye. It is water-soluble, enabling the production of colors such as red, purple, and blue. It also possesses antioxidant activity (Roy and Rhim 2021). Anthocyanin content was determined by assessing the stability of the red color in a qualitative test using 2N HCl and heating (Haq 2021). During heating, OH<sup>-</sup> ions in anthocyanins are released and bind with H<sup>+</sup> ions, resulting in a red-colored solution due to the acidity (Nurchahyo and Febrianti 2019). In this study, anthocyanin content is assessed at 512 nm, which is close to the maximum wavelength of cyanidin-3-glucoside, a commonly employed reference compound for anthocyanins (Herlina et al. 2023). A wavelength of 700 nm is used to account for any potential deposits or impurities present in the sample. In the absence of any impurities, the absorbance at 700 nm will be zero (Lestari and Hamzah 2022).

The results showed that fresh strawberry extract had significantly higher anthocyanin levels than the other samples. It is due to the absence of any processes that could potentially disrupt the integrity of the anthocyanins, such as mixing with other additives (Purwaniati et al. 2020).

Formula 1 contains the highest strawberry concentration among the other formulas; however, it yielded notably lower anthocyanin levels. It might be due to the highly degradable nature of anthocyanins when exposed to heat and light. This reduction makes anthocyanins more susceptible to degradation due to alterations in the chemical milieu during the mixing process (Ifadah et al. 2022). Conversely, increasing the concentration of red beet extract directly enhances the color intensity of the preparation by augmenting the betacyanin pigments (and anthocyanins from strawberries), resulting in a deeper red hue. The pH significantly impacts the stability of anthocyanins, the red-purple pigments found in strawberries. These pigments remain stable only in the flavylium cation form (bright red) in highly acidic pH environments (pH 1-3). However, they rapidly degrade to colorlessness or fade at higher pH levels, approaching neutrality or alkalinity. Other studies have demonstrated that pH changes in anthocyanins cause transitions between the flavylium cation, quinoidal base, carbinol pseudosaccharide, and chalcone forms, each with varying stability and bioactivity (Verma et al. 2023).

**Table 10.** The preference of panelists for the lip tint formulas

Formula	Love it	Like it	Don't really like it	Don't like it
F1	8	7	-	-
F2	4	10	1	-
F3	9	3	3	-



**Figure 3.** Irritation test

**Table 11.** Adhesion of lip tint formulas

Formula	Average time (seconds)	SD	CV%
F1	1.79	0.025	0.014
F2	1.54	0.015	0.010
F3	1.64	0.032	0.020

**Table 12.** Spreadability test result

Formula	Average spreadability (cm)	SD	CV%
F1	6.17	0.289	0.047
F2	7.07	0.115	0.016
F3	7.37	0.404	0.055

**Table 13.** Organoleptic data analysis

Formula	Color	Odor	Homogeneity (+)
First week			
F1	Red	Tutty Fruity	+
F2	Red	Tutty Fruity	+
F3	Pink purple	Tutty Fruity	+
Second week			
F1	Slightly faded red	Tutty Fruity	+
F2	Slightly faded red	Tutty Fruity	+
F3	Slightly faded purple pink	Tutty Fruity	+
Third week			
F1	Faded red	Tutty Fruity	+
F2	Faded red	Tutty Fruity	+
F3	Faded pink	Tutty Fruity	+

**Table 14.** The pH of the lip tint after three weeks of formulation

Formula	Average pH in the third week	SD	CV (%)
F1	4.27	0.02	0.47
F2	4.50	0.03	0.67
F3	4.78	0.05	1.05

The findings demonstrated the successful integration of a natural lip tint formula, primarily composed of red beetroot (a more stable betanin) and enhanced with anthocyanins from strawberries, into a stable and safe preparation. This formulation addresses the growing market demand for clean beauty products. The measured anthocyanin levels demonstrated the resilience of the natural pigments during the formulation process, supported by the selection of castor oil and humectants that safeguard the pigments. Studies on anthocyanin-based lipsticks have indicated that castor oil bases with robust solubilizing capacity are pivotal for preserving pigment stability and antioxidant activity (Westfall et al. 2019). The formulas maintained a stable pH within the physiological range (4.0-6.5), minimizing the risk of irritation while providing strong adhesion to ensure product durability. However, the oil's high viscosity may slightly hinder its spreadability. It implies that the formulas are safe. After an integrated assessment of stability, functionality, and consumer preferences, the optimal formula achieved the ideal equilibrium between color and texture. Notably, F2 demonstrated exceptional performance in fulfilling both functionality and sensory appeal for users.

Several similarities and differences in organoleptic properties are observed in the three lip tint formulas. All formulas were in a liquid state, had a soft texture, and had a consistent, tutty-fruity aroma (Visht et al. 2024). However, there are distinctions in color and texture. Formulas 1 and 2 share a red color, while Formula 3 tends to be purplish pink. In terms of texture, all three formulas exhibit softness. Despite color variations, all three formulas consistently demonstrated comparable aroma and texture. The consistency of certain organoleptic attributes is more strongly influenced by ingredient composition. Moreover, homogeneity led to favorable outcomes (F1, F2, F3), suggesting that the components were uniformly distributed and did not phase separate. It is more likely due to the type of equipment and process used in the formulation, which are crucial prerequisites for maintaining color consistency. It implies that the ingredients in each formula were evenly distributed, eliminating any separation or inhomogeneity. Homogeneity testing is of significant importance in cosmetic product development, ensuring uniformity in color, texture, and desired effects across all product applications (Ainurofiq et al. 2021). The test results indicate that the tested formulas exhibit acceptable, stable, and uniform component distribution.

The pH of the preparation in formula one was found to be below the physiological pH range of the skin, which ranges from 4.5 to 6.5 (Mulyawan and Suriana 2013). This pH level is considered safe and does not irritate the lips. The higher the acidity of a substance that comes into contact with the skin, the more difficult it is to neutralize, potentially leading to dryness, cracking, and increased susceptibility to infection. Consequently, the pH of cosmetics should ideally match or closely approximate the physiological pH of the skin or approach neutrality (Bhure et al. 2025). Lip tint formulations are considered effective if the color adheres to the arm in abundance and is evenly distributed. Conversely, formulations with sparse and uneven color distribution are deemed ineffective (Keithler 2012). The results of this study demonstrate the effectiveness of natural pigments (betalains and anthocyanins) as cosmetic colorants, with pH-dependent stability. This study also shows that using a slow juicer can maintain anthocyanin levels and provides evidence that variations in extract concentration significantly affect the final product's quality. All three formulations demonstrated effective staining, potentially attributed to the higher concentration of beet extract in the lip tint formulation. As the amount of extract increases, the color intensity becomes more pronounced upon application (Purwanto et al. 2019).

Based on these findings, it can be concluded that beetroot and strawberry extract lip tint preparations are safe for use as they do not induce irritation reactions such as itching, redness, or swelling (Yadav et al. 2020). It may be

attributed to the selection of fresh fruit extracts and appropriate processing methods. Both fruits contain high levels of antioxidants that can effectively protect the skin and help minimize irritation. Furthermore, the pH of the lip tint preparation, which falls within the pH range of the lips, significantly influences irritation reactions when it deviates from the prescribed range (Raut et al. 2024).

Adhesion or adhesive strength testing is conducted to assess the adhesive strength of the preparation applied to the target area. Adhesion values exceeding 1 second indicate that the entire formulation has met the minimum standards and can be used functionally as a lip tint product. It adheres to the lips or skin for a sufficient period to produce effective coloring (Nofriyaldi et al. 2025). Spreadability testing evaluates the distribution of lip tint on the skin when applied. Spreadability is considered satisfactory if the lip tint spreads between 5 and 7 cm. The results of the data analysis indicate that F2 and F3 exhibit superior spreading abilities compared to F1, making them more user-friendly and potentially offering more uniform coloring outcomes. These findings demonstrate that the lip tint preparations meet the specified requirements, with diameters ranging from 5 to 7 cm (Tonapa et al. 2021).

By combining all parameters, including the highest anthocyanin concentration, a pH within the physiological range, and satisfactory spreadability, Formula 2 (F2) was concluded as the optimal formula. This finding was supported by quantitative data that demonstrate the optimal balance between physical functionality and the aesthetic characteristics desired by users. The optimal combination of physical properties results in the highest consumer preference.

In conclusion, a lip tint formulation combining red beet and strawberry extracts was developed. The optimal and promising formula was F2, which combined pigments, betanin, and a high total monomeric anthocyanin content. Physicochemical tests showed good pH, adhesion, spreadability, and ease of application, no adverse skin reactions, and good color. The formulation was stable and had high user acceptance for color, aroma, and texture. These natural ingredients provided attractive color and antioxidant compounds for lip health. It concluded that red beetroot and strawberry extracts are potential, effective, safe, and functional natural colorants in cosmetic lip products. The formulation has high commercial potential due to its alignment with the 'Clean Beauty' trend and market demand for natural, safe cosmetic products.

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