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Color cosmetics: Extraction and application of plant based pigments in the formulation of cream blush

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Abstract
The present study focuses on the formulation and evaluation of natural cream blushes using plant-based pigments derived from red sandalwood (*Pterocarpus santalinus*) and beetroot (*Beta vulgaris*). Three formulations were developed: F_1 (beetroot pigment), F_2 (red sandalwood pigment), and F_3 (a combination of both). These natural pigments were extracted using simple, extraction methods and incorporated into a cream base to replace synthetic colorants in cosmetics.
All formulations were evaluated for physical characteristics (appearance, color, odor, texture), physicochemical parameters (pH, total fatty content, residue, thermal stability), microbial, and dermal compatibility. Additionally, FTIR spectral analysis was conducted to confirm the stability and integration of bioactive pigments within the cream base. The results confirmed that all cream blushes exhibited smooth texture, stable pH (6.88-7.45), good thermal stability, and absence of skin irritation. Heavy metal content (lead and arsenic) and microbial load were within permissible cosmetic limits, ensuring product safety. FTIR analysis revealed the presence of functional groups (O-H, C=O, C=C, C-H, and C-O), indicating successful incorporation of pigments without degradation with the cream base. Among the formulations, F_3 exhibited a rich pink shade with slightly moderate color stability compared to F_1 and F_2, which remained more stable.

Keywords: Plant pigments, colour cosmetics, synthetic colourants, stability, evaluation

1. Introduction
In recent years, there has been a growing consumer demand for natural and sustainable cosmetic products, driven by increased awareness of the potential health risks associated with synthetic ingredients. One major area of concern is the use of artificial colorants in cosmetics, which are derived from petroleum-based chemicals and may cause skin irritation, allergies, or long-term health effects [1]. It is important to conduct research on natural pigments and safer substitute colorants because synthetic dyes might have harmful effects [2]. and to explore plant-based alternatives that are not only safe but also rich in bioactive compounds.
The formulation of cream blush, a popular cosmetic product used to impart a natural color to the cheeks, provides an ideal platform to incorporate such plant-based pigments [3]. However, challenges such as pigment stability, compatibility with cream bases, and overall product performance must be addressed to ensure consumer acceptability.
Most of the colors found in makeup products are artificial colors or dyes. Among the synthetic dyes frequently used in cosmetics are azo dyes, xanthone, quinoline, etc [4]. Azo dyes have been found to be more harmful among the different artificial dyes [5]. Three main types of blushes can be used in skin such as loose powder, pressed powder, and cream [6].
This study focuses on the development of a cream blush utilizing natural, plant-based pigments as a safer, eco-friendly alternative to synthetic colorants in cosmetics. Natural pigments, especially those derived from plant, provide multiple advantages including biodegradability, minimal side effects, and added therapeutic benefits such as antioxidant and anti-inflammatory activity [7]. Beetroot (*Beta vulgaris*) is recognized for its rich reddish-purple hue attributed to betalains, a group of water-soluble pigments with notable antioxidant and anti-inflammatory properties. These characteristics not only provide vibrant natural coloration but also contribute to skin protection. Likewise, red sandalwood (*Pterocarpus santalinus*) is a medicinal plant used in Ayurveda, for its santalin pigments and flavonoids, which offer a deep brick-red shade along with skincare benefits such as soothing inflammation and promoting skin tone. Additionally, anthocyanins, found in a wide range of plants, serve as potent antioxidants while imparting attractive red, blue, and purple hues, thus making them ideal candidates for natural cosmetics [8].

By integrating these natural colorants into cream blush formulations, the study aims to create a product that is not only aesthetically appealing but also aligns with consumer preferences for natural colour cosmetics.

1.1. History of colorants and Blush/Rouge

The use of natural colorants can be traced back thousands of years, with ancient civilizations harnessing pigments from minerals, plants, and animals for personal adornment and symbolic expression. One of the earliest recorded pigments is malachite, a green mineral used by the ancient Egyptians around 4000 BCE. It was primarily employed for eye makeup due to its vibrant shade and perceived protective qualities [9]. By the dynastic periods of Egypt (3100-30 BCE), kohl, commonly prepared from galena (lead sulfide), became widely used as a black eye cosmetic. Kohl not only served an aesthetic function but was also believed to protect the eyes from the sun's glare and ward off infections [10].

Among the most prized colorants in antiquity was Tyrian purple, obtained from *Murex* sea snails, considered a symbol of nobility and even mentioned in the Bible. Historical texts also mention the widespread use of madder root for red dyeing, especially in Europe and Asia, and safflower, whose two main dye components carthamidin (yellow) and carthamin (red) were utilized in various applications. Carthamin, also known today as Natural Red 26, continues to be used as a color additive in both food and cosmetics [10, 11]. Today, as the cosmetic industry seeks sustainable and health-conscious alternatives, interest has returned to plant-based pigments like beetroot (*Beta vulgaris*) and red sandalwood (*Pterocarpus santalinus*), valued for their bioactive properties and rich coloration [12].

2. Methodology

Two types of natural pigments beetroot and red sandalwood were extracted using simple, eco-friendly methods and successfully utilized in the development of a natural cream blush. Red sandalwood imparted rich brick-red, orange, and earthy brown tones, while beetroot contributed vibrant rosy and pink hues, resulting in a visually appealing and naturally pigmented cosmetic product. The formulation process involved the careful selection of ingredients, optimization of their proportions, and a methodical approach to ensure desirable texture, stability, and skin compatibility. Multiple trials and evaluations were conducted to confirm that the product was both safe for skin application and functionally effective. Based on the pigment sources, three cream blush variants were developed:

1. Cream Blush using Beetroot Pigments (F_1)
2. Cream Blush using Red Sandalwood Pigments (F_2)
3. Cream Blush using a combination of Red Sandalwood and Beetroot Pigments (F_3)

Each formulation provided a unique aesthetic and functional profile, showcasing the potential of natural plant-based colorants in clean, sustainable cosmetic formulations.

2.1 Materials and Methods

Pterocarpus santalinus, commonly known as red sandalwood or red sanders, belongs to the family *Fabaceae* and contains a rich red dye called 'santalin. The chemical composition analysis of *Pterocarpus santalinus* (Linn.) reveals that it is rich in various bioactive compounds. These include carbohydrates, steroids, anthocyanins, saponins, tannins, phenols, triterpenoids, flavonoids, glycosides, and glycerides [13].

Beta vulgaris is commonly called as beet belonging to family Chenopodiaceae [14]. It is a natural root vegetable, packed with phytochemical and bioactive nutrients [15], vitamins like A, B1, B2, B6, and C. It is also a great source of antioxidants and minerals, including potassium, magnesium, sodium, and vitamin C. Beets come in a range of vibrant colors, from yellow to deep red, and are loaded with beneficial compounds like carotenoids, saponins, beta cyanins, betanin, polyphenols, and flavonoids. The deep red color of beets comes from betalains, which are natural pigments used as food colorants. It's also known for its impressive antimicrobial, antifungal, anti-inflammatory, and antiviral benefits [16].

2.1.1 Red Sandal Wood (*Pterocarpus santalinus)*

To extract pigment from red sandalwood, accurately weighed 10 grams of red sandalwood powder and transferred it into a clean, ethanol-rinsed double-neck round-bottom flask. Added 200 grams (w/w) of 95% ethanol to the flask, ensuring a solvent-to-powder ratio of 20:1. Assembled the reflux setup by connecting a reflux condenser to one neck of the flask and inserting a thermometer through the side neck to monitor the temperature. Placed the flask on a heating mantle and initiate steady water flow through the condenser. Heated the mixture at a controlled temperature of 50 °C for 6 hours to facilitate the extraction of pigment compounds. After the extraction period, allowed the mixture to cool slightly and filtered it using filter paper to separate the liquid extract. Pressed the solid residue using a muslin cloth or mechanical press to recover any remaining extract. Combined the filtrates and evaporate the solvent on a hot plate maintained at 50 °C until a concentrated extract is obtained. This concentrated red sandalwood extract can be used as a natural pigment or colorant in cosmetic formulations.

2.1.2 Beet Root (*Beta vulgaris*)

A fresh beetroot is first thoroughly washed to remove any dirt or impurities. The outer skin is peeled off, and the beetroot is finely grated to provide efficient juice extraction. The grated beetroot is then placed in a clean muslin cloth and squeezed to obtain the juice. The extracted juice is transferred to a container and gently heated on a hot plate at 70 °C to concentrate it. The heating continues until the volume is reduced to one-fourth of the original, resulting in a rich, concentrated beetroot extract. This natural extract can be used as a pigment in cream blush formulations, imparting a vibrant reddish-pink hue.

Table 1: Formulation of cream blush

S. N.	Ingredients	F_1% w/w	F_2% w/w	F_3% w/w
Phase A (Oil Phase)				
1	Stearic acid	18.5	18.5	18.5
2	Cetyl alcohol	2.0	2.0	2.0
Phase B (Water phase)				
3	Glycerin	33	33	30
4	Tri-ethanolamine	1	1	1
5	Water	18	21	-
6	Sodium benzoate	1	1	1
7	Citric acid	1	1	1
Phase C				
8	Kaolin clay	0.5	0.5	0.5
9	Perfume	q.s	q.s	q.s
10	Red sandalwood extract	25	-	6.0
11	Beetroot extract	-	22	40
12	Perfume	q.s	q.s	q.s

2.2 Formulation of Cream blush base

To prepare the cream blush base, started with formulating the oil phase. In a clean beaker, combined stearic acid, cetyl alcohol. Heated the mixture to 70-75 °C while stirring continuously until all components are completely melted and form a homogeneous blend. Simultaneously, in a separate beaker, prepared the water phase by mixing purified water, glycerin, Sodium benzoate and triethanolamine, and heated this mixture to the same temperature range of 70-75 °C. Once both phases are at the desired temperature, slowly added the oil phase to the water phase with constant stirring to initiate emulsification. Continue mixing using a high-shear mixer until a uniform emulsion forms. After emulsification, allow the mixture to cool gradually to below 40 °C. At this point, incorporated the concentrated natural pigment, and fragrance if desired. Mixed gently until all ingredients are evenly dispersed. Finally, poured the prepared cream blush base into clean, sterilized containers and allowed it to cool and packed in airtight contained.

Fig 1: Application of formulated cream blush on skin

3. Characterization of Cream Blush

The characterization of the cream blush is performed in accordance with the standards set by the Bureau of Indian Standards (BIS), IS 6608:2004 [19], which specifies the requirements and methods of testing for skin creams. This ensures that the product meets quality, safety, and performance benchmarks, including parameters such as pH, thermal stability, total fatty substance, spreadability, total residue, stability, microbial limits, and skin irritation potential. The organoleptic properties was evaluated by observing its appearance, color, odor, texture [20].

3.1 Determination of pH

Accurately weighed 5.01 grams of the cream and transferred it into a 100 ml clean beaker. Added 45 ml of distilled water to the beaker and stirred the mixture thoroughly until the cream is completely dispersed and forms a uniform solution. Measured the pH of the resulting mixture using a calibrated pH meter at a controlled temperature of 27 °C. Ensured the pH meter is properly standardized with buffer solutions before use for accurate results.

3.2 Test for thermal stability

Using a clean spatula, transferred the cream into a dry glass bottle, tapping it gently to ensure the product settles evenly at the bottom. Filled the bottle to approximately one-third of its capacity. Secured the inner plug and tightened the screw cap firmly to prevent leakage. Placed the bottle in an upright position inside an incubator maintained at 45 ± 1 °C for a duration of 48 hours. After the incubation period, carefully removed the bottle and observed the cream for any signs of instability. The cream is considered to have passed the thermal stability test if there is no visible oil separation, creaming, cracking, or any form of phase separation.

3.3 Test for total fatty substance content

Accurately weighed about 2 grams of the cream sample into a clean conical flask. 25 ml of dilute hydrochloric acid is added to the flask, attached a reflux condenser, and boiled the mixture gently until the solution becomes completely clear, indicating complete breakdown of the emulsion. Carefully transferred the hot solution into a 300 ml separating funnel and allowed it to cool to room temperature. Rinsed the conical flask with a total of 50 ml of petroleum ether, added in 10 ml portions, and transferred each rinse to the separating funnel. Shaked the funnel thoroughly and allowed the aqueous and organic layers to separate. Discarded the aqueous layer and extracted it twice more using 50 ml portions of petroleum ether. Combined all petroleum ether extracts and washed them repeatedly with distilled water until the washings show no acidity, as confirmed by the absence of a pink color when tested with methyl orange indicator solution.

Finally, evaporated the combined petroleum ether extract to dryness and weighed the residue to determine the total fatty substances.

3.3.1 Calculation

Total fatty substance, percent by mass = $(100 \times M_1) / M_2$

Where:

M_1 = mass (in grams) of the residue obtained after evaporation of petroleum ether, M_2 = mass (in grams) of the original sample taken for the test

3.4 Determination of Total Residue

Accurately weighed approximately 2 grams of the cream sample into a clean, dry, squat-shaped weighing bottle. Placed the bottle in a hot air oven and dried the sample at 105 ± 1 °C until a constant weight is achieved. After drying, removed the bottle and allowed it to cool in a desiccator to prevent moisture absorption. Once cooled, weighed the bottle again. The difference in weight before and after drying gives the amount of volatile matter lost, and the remaining weight represents the residue, which may include non-volatile components such as minerals, pigments, or waxes.

Total Residue percent by mass = $(100 \times M_1) / M_2$

Where

Ml = mass in g of the residue, and

M2 = mass in g of the material taken for test

3.5 Test for heavy metals

A known quantity of the cream sample was first incinerated in a muffle furnace to obtain ash, ensuring complete removal of organic matter. The resulting ash was then subjected to acid digestion using a mixture of concentrated acids (typically nitric acid and perchloric acid) to break down the inorganic matrix and bring the heavy metals into solution. After complete digestion, the solution was filtered and diluted to a known volume with distilled water. The prepared sample was then analyzed using Atomic Absorption Spectroscopy (AAS) to determine the concentrations of heavy metals such as lead (Pb) and arsenic (As). This test ensures the product complies with permissible limits set by safety and quality standards.

3.6 Homogeneity Test

To evaluate the homogeneity of the cream blush, a small amount of the sample was evenly spread on a clean piece of glass or another transparent surface. The applied layer was then visually examined under natural or adequate artificial light to assess the uniformity of the formulation. The sample was observed for any signs of coarse particles, graininess,

streaks, or phase separation. A smooth, consistent appearance without any visible irregularities indicates good homogeneity and proper dispersion of ingredients in the cream base [21].

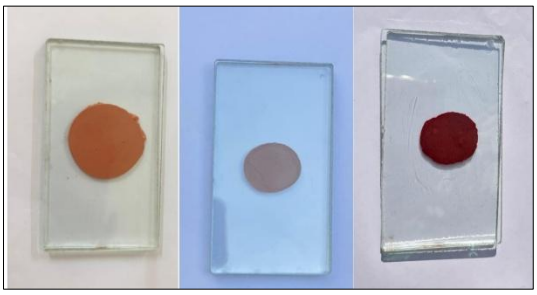

Fig 2: Homogeneity of cream blush

3.7 Polishing Test

To assess the color payoff and blending quality of the cream blush, the sample was applied in three consecutive layers to the inner side of the arm. Each layer was gently spread and allowed to set before applying the next. The resulting area was then observed for the intensity, uniformity, and smoothness of the color effect. This test helps evaluate the buildability, finish, and aesthetic appeal of the cream blush when applied to the skin, ensuring it delivers a desirable and consistent tint without patchiness or unevenness.

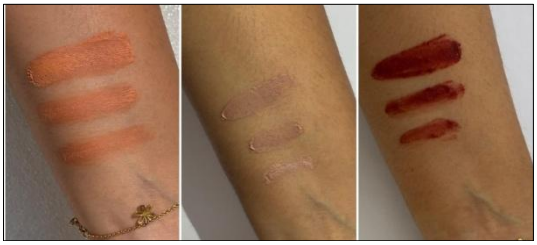

Fig 3: Polishing test of cream blush

3.8 Skin Irritation Test

To assess the potential for skin irritation, a small amount of the cream blush was applied to a clean and dry area of the inner forearm or behind the ear. The test site was left undisturbed and observed for any signs of adverse reactions such as redness, itching, burning sensation, swelling, or rash over a period of 24 hours. The absence of any visible symptoms within this observation period indicates that the formulation is non-irritant and safe for topical application on normal skin [20].

Fig 4: Skin irritation of cream blush

3.9 Colour Stability

All three cream blush formulations (F_1, F_2, and F_3) were tested for color stability under various storage settings to determine how resistant they were to fade or discoloration over time. For 30 days, the samples were kept at room temperature, at a higher temperature (45 ± 2 °C), and in direct sunlight. At regular intervals (Day 0, 7, 15, and 30), visual observations were documented.

3.10 FTIR Spectrum of Pigments and formulated Cream Blush

FTIR analysis was conducted using a Perkin Elmer Spectrum 2 FTIR Spectrometer in the wavenumber range of 4000 cm^{-1} to 400 cm^{-1} to identify the functional groups present in the plant-based pigments, namely beetroot and red sandalwood, as well as in the formulated cream blush. The analysis aimed to determine the retention and interaction of functional groups during formulation.

4. Results and Discussion

Three cream blush formulations (Beetroot-based (F_1), Red sandalwood-based (F_2), and Combination of both pigments (F_3) were evaluated for their cosmetic properties, safety parameters, and performance. All formulations displayed visually appealing appearance, with F_2 and F_3 rated as particularly attractive due to their rich natural pigmentation. The color tones ranged from peach (F_1), peachy pink (F_2), to pink (F_3), providing variety in shade options. All samples exhibited a pleasant fragrance and maintained a smooth, creamy texture, desirable for easy skin application.

The formulations demonstrated excellent thermal stability, showing no phase separation under stress conditions. The pH values were within the acceptable dermal range (4-9), with F_1 at 7.00, F_2 at 6.88, and F_3 at 7.45, indicating skin compatibility. The total fatty content exceeded the minimum 5% requirement in all samples, with F_3 having the highest content (20%), likely contributing to its richer texture and emollient effect. Total residue values were also within acceptable limits, supporting adequate pigment dispersion and cream base retention.

Heavy metal analysis showed lead and arsenic levels within the safe cosmetic limits, confirming the non-toxic nature of the plant-based pigments. Microbial tests revealed that all formulations had total viable counts below the quantification limit (BLQ, LOQ-10) and were free from Gram-negative pathogens, ensuring microbiological safety.

No skin irritation was observed in any formulation during testing, confirming their dermatological safety. In terms of colour stability, F_1 and F_2 remained stable across conditions, whereas F_3 showed moderate fading under prolonged exposure to sunlight, likely due to the beetroot pigment's sensitivity.

Overall, the results confirm that all three cream blush formulations are safe, stable, and skin-friendly, with formulation F_2 (red sandalwood) showing the best balance of aesthetic texture colour retention, and safety, while F_3 provide a vibrant shade with good performance with a natural ingredient benefit.

Table 2: Evaluation parameters of cream blush

S. No.	Characters	Requirements	F_1	F_2	F_3
1.	Appearance	-	Good	Attractive	Attractive
2.	Color	-	Peach	Peachy pink	Pink
3.	Odor	-	Fragrant	Fragrant	Fragrant
4.	Texture	-	Smooth	Smooth	Smooth
5.	Thermal stability	No phase separation	Passed	Passed	Passed
6.	pH	4 to 9	7.00	6.88	7.45
7.	Total fatty content	Min 5% per mass	18.21	10.15	20
8.	Total residue	Min 10% per mass	50%	20%	35%
9.	Heavy metals (lead)	Max 20 ppm	5.0 ppm	5.21 ppm	5.4 ppm
10.	Arsenic	Max 2 ppm	0.55 ppm	0.57	0.60 ppm
Microbial/limit					
11.	Total viable count cfu/g	Not more than 1000	BLQ(LOQ-10)	BLQ(LOQ-10)	BLQ(LOQ-10)
12.	Gram negative pathogens	Less than 10	Absent	Absent	Absent
13.	Skin Irritation	Mild/Moderate	No irritation	No irritation	No irritation
14.	Colour stability	Stable	stable	stable	Moderate

4.1 FTIR Spectrum of Pigments and formulated Cream Blush

The FTIR spectra confirm the successful incorporation of beetroot pigment into the cream blush without significant degradation.

4.1.1. Beetroot Pigment: The FTIR spectrum of the beetroot pigment displayed a broad and intense peak at 3346.25 cm^{-1} (64.38%T), indicative of O-H stretching vibrations, commonly associated with hydroxyl groups found in phenolics and alcohols. Peaks observed at 1635.49 cm^{-1} and 1595.23 cm^{-1} (77.19%T and 79.18%T) correspond to C=C stretching of aromatic rings or C=O stretching from conjugated ketones, suggesting the presence of betalains and flavonoids. A prominent peak at 1544.95 cm^{-1} (78.78%T) may represent N-H bending or C=N stretching, possibly arising from amine or imine functionalities. The signal at 1387.31 cm^{-1} (71.70%T) is attributed to C-H bending in alkanes or O-H deformation. Additional peaks at 1108.96, 994.75, and 925.82 cm^{-1} confirm C-O stretching vibrations, indicative of carbohydrate moieties present in the pigment matrix.

4.1.2. Formulated Beetroot based Cream Blush: In the formulated cream blush spectrum, the O-H stretching peak appears at 3325.28 cm^{-1} (71.78%T), slightly shifted and with reduced intensity due to interactions with cream base constituents. New peaks at 2917.78 cm^{-1} and 2850.16 cm^{-1} (86.52%T and 90.28%T) indicate C-H stretching vibrations, characteristic of long-chain fatty acids and hydrocarbons, confirming the presence of emollients or stearic acid used in the cream formulation. The C=O and C=C stretching bands are retained at 1641.11 cm^{-1} and 1547.60 cm^{-1} (86.10%T and 91.35%T), confirming the structural stability of the beetroot pigment post-formulation. The persistent C-H and O-H deformation vibrations are observed at 1388.37 cm^{-1} (85.35%T). Furthermore, peaks at 1110.62, 1040.07, 993.16, and 925.54 cm^{-1} represent C-O stretching typical of esters, polysaccharides, and other carbohydrate-based compounds.

The key functional peaks of beetroot pigment notably at 1595-1635 cm^{-1} (C=C/C=O) and 3346 cm^{-1} (O-H)-are clearly retained in the cream blush formulation, confirming the presence and integrity of the bioactive colorant. The appearance of additional peaks between 2850-2917 cm^{-1} in the blush formulation corresponds to cream base ingredients, such as fatty acids and esters. Importantly, no new peaks are observed in the blush spectrum, indicating no chemical incompatibility or degradation occurred during the formulation process.

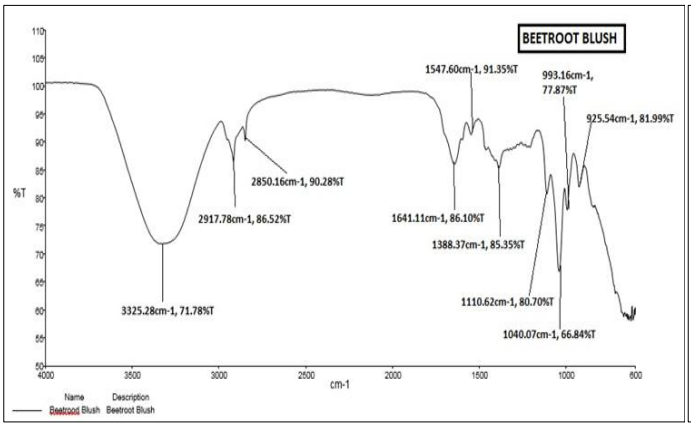

Fig 5: FTIR Spectrum of Beet Root Pigments

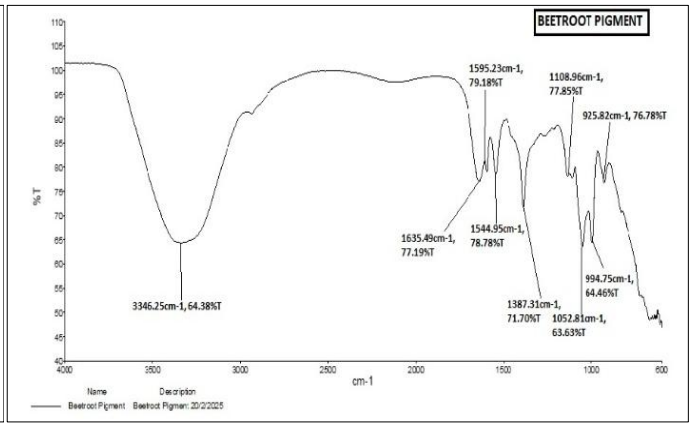

Fig 6: FTIR Spectrum of Beet root Cream Blush

4.2 FTIR Spectrum of Red Sandal wood Pigments and formulated Cream Blush

The FTIR spectra confirm the successful incorporation of red sandalwood pigment into the cream blush without major structural degradation.

4.2.1. Red Sandalwood Pigment

The Broad O-H stretching at 3347.38 cm^{-1} (78.75%T), indicative of phenolic -OH groups commonly found in flavonoids and polyphenolic compounds. The C-H stretching vibrations at 2975.12 & 2829.91 cm^{-1} (80.75%T & 86.66%T) associated with aliphatic chains or CH_3/CH_2 groups. C=O

stretching or C=C stretching in aromatic rings at 1645.36 cm^{-1} (85.09%T), likely due to conjugated carbonyl groups present in naphthoquinones like santalin. The peak at 1380.35 cm^{-1} (79.88%T) indicate Bending vibrations of O-H or CH_3 groups. The peak 1323.78 cm^{-1} (81.01%T) confirms the C-N stretching of aromatic amines or possible contributions from phenolic ethers. 1086.98 cm^{-1} (64.80%T) confirms the C-O stretching of alcohols or ethers. The peak at 1045.38 cm^{-1} (45.48%T), 879.32 cm^{-1} (63.41%T) indicate C-H out-of-plane bending from aromatic rings, supporting presence of substituted aromatic systems.

4.2.2. Formulated Red Sandalwood based Cream Blush

The FTIR spectral analysis of the cream blush formulated with red sandalwood pigment provides clear evidence of the successful integration and stability of bioactive compounds within the cream matrix. A broad O-H stretching peak at 3342.80 cm^{-1} (67.17%T) suggests strong hydrogen bonding interactions, likely between hydroxyl groups from the red sandalwood pigment and hydrophilic components of the cream base such as water and emollients. The C-H stretching peaks observed at 2916.39 cm^{-1} and 2849.42 cm^{-1} (86.21%T and 89.77%T) indicate the presence of long-chain hydrocarbons, typically derived from fatty acids, esters, or waxes commonly used as emollients and structuring agents in cosmetic creams.A significant peak at 1645.66 cm^{-1} (84.65%T) corresponds to C=O or C=C stretching vibrations, characteristic of the conjugated systems in red sandalwood pigments, indicating the pigment's chemical stability post-formulation. The CH_2 bending vibration at 1410.87 cm^{-1} (86.94%T) further confirms the presence of fatty constituents from the cream base. Additionally, peaks at 1111.14 cm^{-1} and 1041.78 cm^{-1} (81.60%T and 66.99%T) are attributed to C-O stretching, which can be associated with esters, glycosidic linkages, or excipients used in cream formulations. Notably, peaks at 993.68 cm^{-1} and 925.58 cm^{-1} (81.82%T and 82.54%T) suggest aromatic out-of-plane bending and polysaccharide-related vibrations, which may be linked to natural polymeric substances in the pigment or stabilizers in the formulation.

Overall, the FTIR spectrum confirms that the key functional groups from red sandalwood pigment such as O-H, C=O/C=C, and aromatic rings-are well preserved in the cream blush. The presence of peaks from the cream base (notably in the 2900-2850 cm^{-1} region) without any additional or unexpected signals confirms the chemical compatibility and non-reactivity between the pigment and cream constituents. This validates the stability, integrity, and suitability of red sandalwood pigment as a natural, effective, and safe colorant for use in cosmetic cream blush formulations.

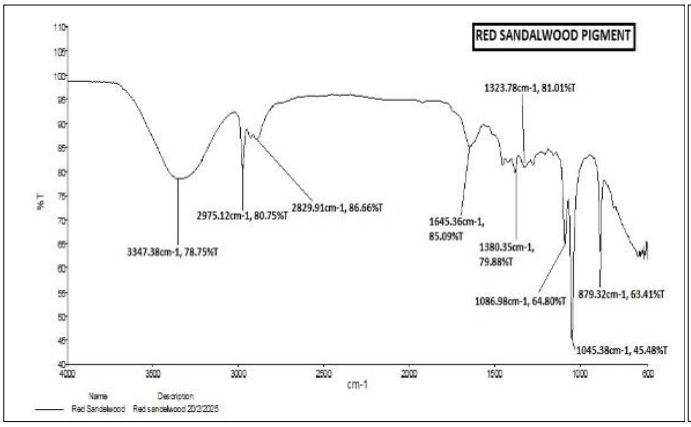

Fig 7: FTIR Spectrum of Red sandalwood Pigments

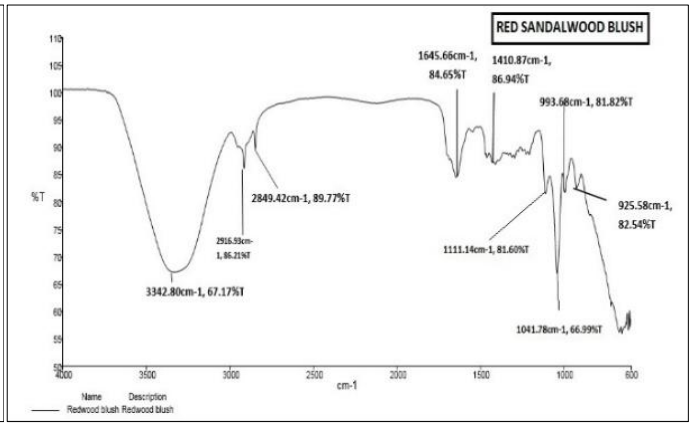

Fig 8: FTIR Spectrum of Red sandalwood based cream blush

4.3 FTIR Spectrum of Cream Blush Formulation developed with both red sandalwood and beetroot pigments

The FTIR spectrum of the cream blush formulation developed using a combination of red sandalwood and beetroot pigments reveals distinct absorption peaks that confirm the presence of various functional groups associated with natural plant-based pigments and cream matrix components. A broad and prominent peak observed at 3333.87 cm^{-1} corresponds to O-H stretching vibrations, indicative of hydroxyl groups typically found in phenolic compounds such as flavonoids in red sandalwood and betalains in beetroot. This also suggests the presence of water or moisture from the cream base. A peak at 2971.29 cm^{-1} represents C-H asymmetric stretching, commonly associated with aliphatic -CH_2 and -CH_3 groups, likely originating from fatty acid chains or emollients in the cream base. The absorption bands at 1644.27 cm^{-1} and 1550.34 cm^{-1} are assigned to C=O/C=C stretching and N-H bending vibrations, respectively. These are characteristic of aromatic rings and amide or amine functional groups present in the pigments, indicating the presence of conjugated structures essential for color and antioxidant activity.

Additional peaks at 1387.33 cm^{-1} and 1110.32 cm^{-1} correspond to CH_3 bending and C-O stretching vibrations, confirming the presence of esters, glycosidic linkages, or alcohols. The bands observed at 1041.27 cm^{-1}, 994.08 cm^{-1}, and 924.91 cm^{-1} relate to C-O-C ether stretches and aromatic C-H bending, supporting the stability of aromatic compounds and esterified constituents.

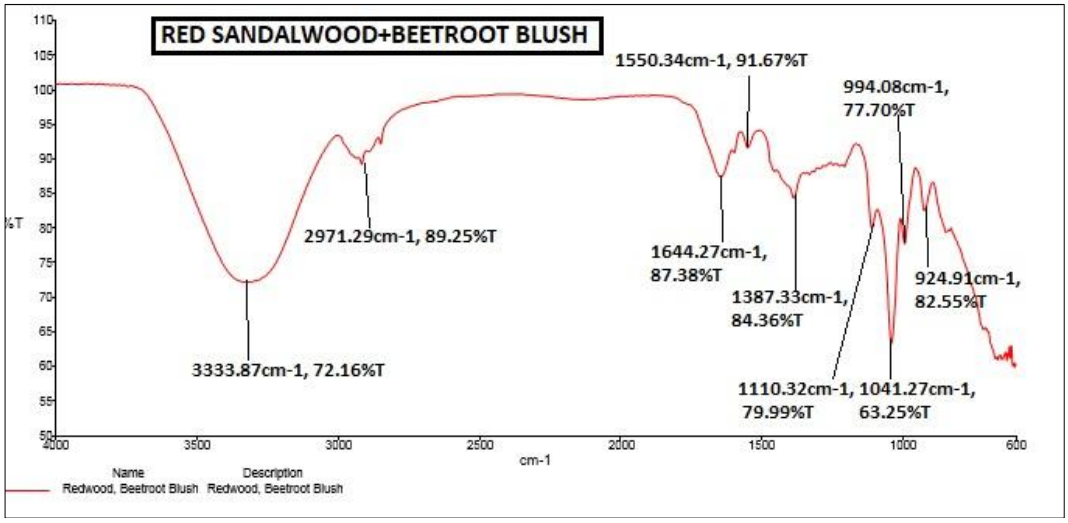

Fig 9: FTIR Spectrum of formulated cream blush using both Red sandalwood and beetroot pigments

Overall, the FTIR analysis confirms that the cream blush formulation retains the functional groups of bioactive pigment molecules without any major chemical interaction or degradation during formulation. The characteristic peaks from both red sandalwood and beetroot pigments are well-preserved, validating their successful incorporation into a cosmetically stable and functionally active cream blush product.

5. Conclusion

The study successfully demonstrated the development of cream blush formulations using two natural pigments beetroot, red sandalwood individually and in combination, providing a natural and safe alternative to synthetic cosmetic colorants. The formulations (F_1, F_2, and F_3) were prepared using simple extraction and blending techniques, resulting in aesthetically pleasing cream blushes with varying shades F_1 (Peach), F_2 (Peachy Pink), and F_3 (Pink). All three formulations met the essential physicochemical quality parameters, including smooth texture, pleasant fragrance, and thermal stability without phase separation. The pH values were within the acceptable dermal range (4-9), indicating skin compatibility. The total fatty content and residue met the expected cosmetic formulation benchmarks, particularly in F_3, which showed the highest values, contributing to good skin feel and color payoff. FTIR spectral analysis confirmed the successful incorporation of the plant pigments into the cream base without structural degradation or chemical incompatibility. Skin irritation tests confirmed all formulations were non-irritating, supporting their use in topical applications. The overall results validate the potential of using beetroot and red sandalwood as sustainable, bioactive colorants in natural cosmetic formulations. These cream blushes are not only safe and effective but also align with the rising consumer demand for eco-friendly and plant-based cosmetic products.

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