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Preparation and evaluation of natural lipstick from beetroot (*Beta vulgaris*) extract medicated with acyclovir

H. Bava Bakrudeen[1], Yasmin Khambhaty[2], Madurai Suguna Lakshmi[3] & Tamilselvi Alagumuthu[4]*

[1]Unit of Pharmaceutical Technology, AIMST University, 08100 Bedong, Kedah, Malaysia
[2]Environmental Science Lab, CSIR-Central Leather Research Institute, Chennai 600 020, Tamil Nadu, India
[3]Polymer Science and Technology Division, CSIR-Central Leather Research Institute, Chennai 600 020, Tamil Nadu, India
[4]Unit for Science Dissemination, CSIR-Central Leather Research Institute, Chennai 600 020, Tamil Nadu, India
*E-mail: tamilselvi@clri.res.in

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The purpose of this study is to address the health concerns associated with heavy metal contaminants in traditional lipstick formulations. The objective is to develop a safer alternative to conventional lipsticks while ensuring stability and efficacy. The medicated lipstick has been successfully synthesized using a dispersion method, with oil serving as the dispersing media. Incorporation of beetroot powder extract imparted colour to the lipstick, while acyclovir drug has been effectively integrated into the formulation. Particle size analysis revealed that the lipstick particles ranged from 300 nm to 600 nm, with an average particle size of 407 nm, indicating suitable dispersion and homogeneity. Stability studies conducted over a period of 35 days demonstrated good stability of the products, suggesting its potential for long-term use. Further, different colour lipstick was synthesized with the same stability by altering the oil and beetroot extract composition. In conclusion, this study highlights the potential of natural ingredients and pharmaceutical additives in cosmetic formulations to enhance safety and efficacy, paving the way for further research and development in this area.

Keywords: Acyclovir, Beetroot extract, Characterization, Lipstick formulation, Medicated lipstick

Introduction

In the ever-evolving world of science and technology, cosmetics hold a prominent position in human attraction. Cosmetics, including herbal preparations, are widely used to enhance the appearance of the human body, and herbal cosmetics have gained significant popularity in the global market[1,2]. The demand for herbal products, such as herbal tablets, tonics, shampoos, contraceptives, and lipsticks, has been steadily growing[3]. Lipstick, in particular, is a widely used beauty product available in various shades and textures[4, 5].

While colouring lips has been a practice dating back to prehistoric times, the application of lipstick on dried, cracked lips with sores and lesions can be challenging[6]. Moreover, synthetic dyes used in lipstick formulations can have harmful effects on human health, especially due to the presence of heavy metal contaminants[7,8]. These heavy metals, such as lead, can pose long-term health risks, including stomach tumors and neurological issues. To mitigate these adverse effects, the use of natural compounds in cosmetic formulations has gained attention[9-11]. One such natural source of red dye is *Beta vulgaris* commonly known as beetroot, which can be used as an alternative to synthetic dyes. Betanin, the main component of the red color extracted from beetroot, holds the potential for use in lipsticks[12]. Additionally, the incorporation of medicinal properties into lipsticks can serve as a therapeutic delivery system for lip infections[13].

Previous studies have explored the formulation of natural lipsticks using herbal ingredients[14]. The effect of different natural ingredients on various evaluation parameters has been investigated, revealing minimal or no side effects and maximum local effects on the lips. Additionally, medicated lipsticks loaded with acyclovir have been developed for effective topical delivery to combat herpes simplex infections. The quality of lipsticks is directly related to the composition of the formulation, allowing manipulation of their physical properties. Therefore, the present study aims to develop a medicated lipstick using beetroot powder incorporated with acyclovir, which can prevent the side effects associated with synthetic preparations[15,16]. This product offers women in our society the opportunity to enhance their appearance with minimal or no side effects.

Experimental Section

Beetroot samples were obtained from the local market. Locally sourced beeswax and paraffin wax were procured from the Chennai market. DL-α-Tocopherol, purchased from Alfa Aesar, England, was of analytical grade. Extra virgin olive oil obtained from Welkraft Consulting Pvt. Ltd, Chennai, India was of food-grade quality. Vanilla essence, acquired from Bakers colours and flavors Company of India. *Beta vulgaris* samples were collected from the local market. Thermogravimetric analysis (TGA) was done using STA 449 F3 Jupiter thermal analyser (Netzsch, Germany) heating 30-600 °C using an aluminium pan at the heating rate of 10 K/min under a nitrogen atmosphere with the flow rate of 80 mL/min. The z-average size of the lipsticks components was measured by Dynamic Light Scattering (DLS) (Nano ZS, Malvern Instruments).

Preparation of beetroot powder

The beetroot was sliced into thin strips and placed on a dehydrator screen for overnight drying. Once completely dried, the strips were ground into fine powder using a mixer (Fig. 1). The resulting beetroot powder was carefully stored in an airtight glass container for subsequent analysis and experimentation.

Preparation of lipstick base and dispersion of beetroot powder

To prepare the lipstick base, locally sourced beeswax, and paraffin wax were used. The waxes were taken in a 1:1 ratio (w/w) in a beaker. The wax mixture was melted at a temperature of 90 °C using an oil bath. The melted wax was kept at this temperature for a few minutes to ensure complete homogenization. Olive oil was used as a blending agent to incorporate the wax and oil phases. Half of the total amount of olive oil was allocated for pigment dispersion. Beetroot powder (2.5 g) was mixed with the olive oil, ensuring equal dispersion, and subjected to sonication for 1 min.

Preparation of lipstick mixture

The mixture of beeetroot powder and olive oil obtained above was added slowly to the prepared lipstick base while homogenizing at 3000 rpm using a homogenizer until the wax phase and oil/pigment phase were equally dispersed. To enhance the antioxidant properties of the lipstick, 0.7 g of DL-α-Tocopherol, vitamin E was incorporated into the mixture and mixed well for 1 min using the homogenizer.

Incorporation of drug

200 mg of acyclovir drug was taken and mixed with the remaining portion of olive oil. The drug was dispersed using sonication for 1 min, resulting in a creamy yellow mixture. The temperature was reduced to 70 °C to prevent drug degradation. The drug mixture was then added to the prepared lipstick mixture and homogenized until the drug was uniformly dispersed within the lipstick base.

The lipstick formulation involves the careful selection and combination of ingredients to prepare the lipsticks as given section-wise in Table 1.

Flavouring and finishing

Vanilla essence was used as a flavoring agent in the formulation of the medicated lipstick. Around 0.2 g of vanilla essence was added to the above mixture and mixed for 1 min, ensuring proper incorporation. The hot lipstick mixture was promptly poured into a suitable mold and placed in a refrigerator for cooling and solidification. Once cooled, the finished lipstick product was gently removed from the mold by pushing on one side of the lipstick, allowing it to slide out smoothly.

Quality assessment and parametric evaluation of formulated medicated lipstick

The formulated lipsticks were subjected to parametric evaluations such as colour analysis, pH measurement, skin irritation test, surface anomalies examination, aging stability, solubility, and perfume stability to find out their suitability and quality in applications.

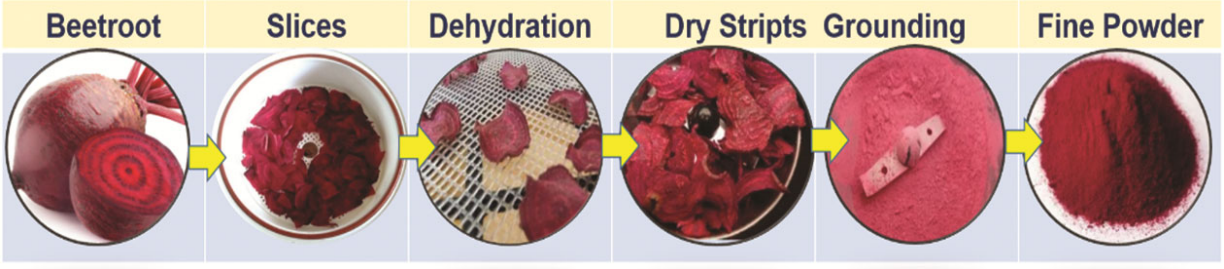

Fig.1 — Process for preparation of beetroot powder

Breaking point test

The breaking point test was conducted to evaluate the strength of the formulated medicated lipstick. The breaking point was determined by following the procedure outlined in ASTM D4839 and ISO 22776:2019. The lipstick sample was prepared according to the specified formulation and allowed to solidify. For the breaking point test, the lipstick was held horizontally in a socket positioned ½ inch away from the edge of the support. A gradual increase in weight was applied to the free end of the lipstick at specific intervals of 30 s. The weight was increased by a predetermined value such as e.g., 10 g at each interval. The test was continued until the lipstick reached its breaking point, at which it fractured or separated. The weight at which the lipstick broke was recorded as the breaking point, representing the strength of the lipstick sample (Fig. 2).

Softening point and solubility test

The softening point of the formulated lipsticks was determined by the ring and ball method (Fig. 3). The solubility test was performed by dispersing the lipstick in different solvents such as ethanol, chloroform, etc.

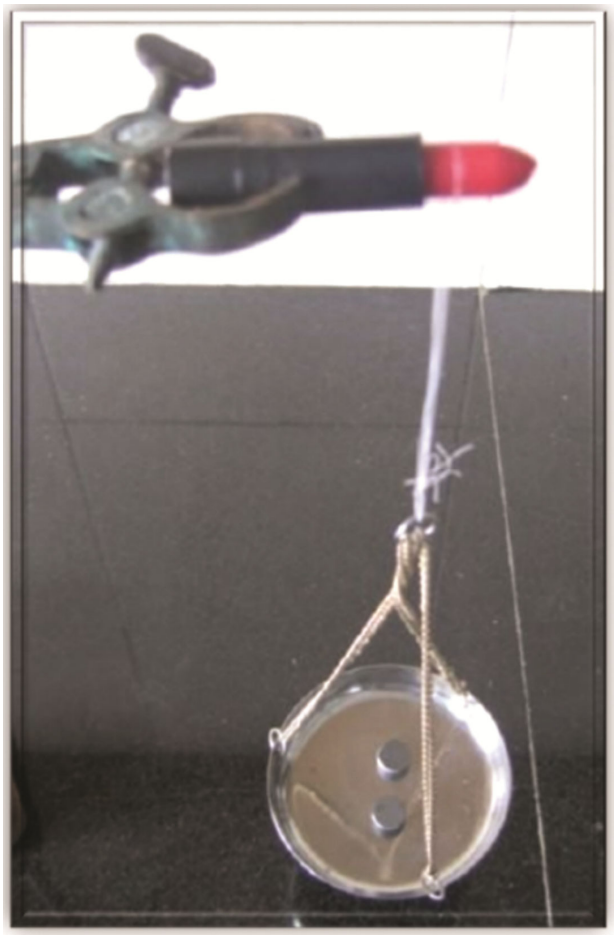

Fig. 2 — Experimental setup for breaking point analysis

Surface anomalies and pH parameter

The presence of surface anomalies, such as crystals or contamination by molds and fungi, can affect the overall quality and appearance of the lipstick. In this study, the prepared lipsticks were examined for surface anomalies and its pH was determined.

Aging stability and skin irritation test

The stability of the lipsticks was assessed by subjecting them to different temperature conditions, including 4 °C, 20-25 °C, and 30-40 °C. The lipsticks were observed for any effects such as sweating (formation of moisture droplets), bleeding (colour spreading), streaking (uneven distribution), and blooming (wax separation). A skin irritation test was conducted by applying the formulated herbal lipstick on the skin for duration of 10 min. This test aimed to evaluate the potential irritancy or sensitivity of the lipstick formulation on the skin, ensuring its safety for use.

Perfume stability

Perfume stability of the herbal lipstick formulation was evaluated post-30 days, ensuring the longevity and consistency of its fragrance, a vital aspect of consumer satisfaction.

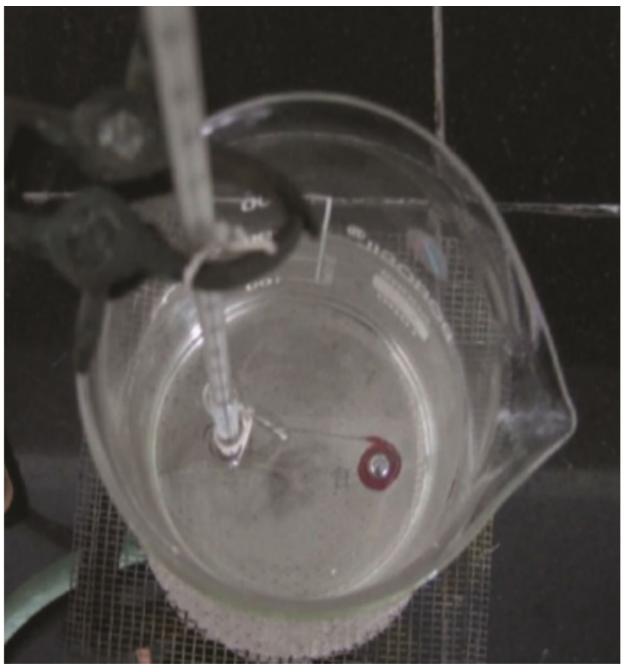

Fig. 3 — Experimental setup for softening point analysis

Thermal analysis

Differential Scanning Calorimeter (DSC) measurements were conducted to investigate the heat flow characteristics and qualitative analysis, particularly the melting points, of the plain lipstick, beetroot powder-added lipstick, and medicated lipstick, which were compared to the pure acyclovir drug. Thermogravimetric analysis (TGA) was performed to evaluate the thermal stability of the different lipstick samples, including the medicated lipstick, unmedicated lipstick, lipstick with beetroot powder, pure beetroot powder, and acyclovir drug. The objective was to compare their thermal behaviour against the control sample, which consisted of plain lipstick.

Particle size analysis

Particle size analysis was performed on the medicated lipstick formulation to assess the distribution and size of particles present.

Results and Discussion

The medicated lipstick incorporated with acyclovir drug was prepared followed by the characterization of the formulated product.

Composition and significance of ingredients

Table 1 presents the composition and significance of each ingredient used in the preparation of the medicated lipstick. Beeswax and paraffin wax are included in equal proportions (20% each) to provide a glossy appearance and ensure hardness in the lipstick formulation. These waxes play a crucial role in giving the lipstick its desired texture and structural integrity. Olive oil, constituting 47.4% of the formulation, acts as a blending agent. It aids in the dispersion of the waxes, pigments, and other components, resulting in a smooth and cohesive mixture. The high percentage of olive oil contributes to the creamy texture of the lipstick. Beetroot is incorporated as the colouring agent, contributing 9.2% to the formulation. Its natural pigment imparts a vibrant colour to the lipstick, creating an appealing visual effect on the lips. Tocopherol, present at 2.6%, acts as an antioxidant. It helps in preserving the stability and extending the shelf life of the lipstick by protecting it from oxidation and rancidity Acyclovir, an antiviral agent, is included in the formulation at a concentration of 0.7%. Its incorporation in lipstick is significant as it provides potential therapeutic benefits, specifically in preventing Herpes viral infections. Vanilla essence, added at 0.7%, serves as the flavouring agent. It imparts a pleasant scent and taste to the lipstick, enhancing the overall sensory experience for the user. Overall, the composition of the medicated lipstick formulation was carefully designed to ensure not only aesthetic appeal but also functional benefits such as colour, texture, stability, and potential therapeutic effects.

Table 1 — Preparation of medicated lipsticks

Ingredients	Quantity (g)	Percentage (%)	Importance
Beeswax	5.4	20	Glossy and hardness
Paraffin wax	5.4	20	Glossy and hardness
Olive oil	12.8	47.4	Blending agent
Beetroot (Beta vulgaris)	2.5	9.2	Colouring agent
Tocopherol	0.7	2.6	Antioxidant
Acyclovir	0.7	0.7	Antiviral agent

Lipstick formulation involves the careful selection and combination of ingredients to achieve desirable physical and sensory properties. This study aimed to develop a medicated lipstick formulation and evaluate its characteristics, including hardness, shine, spreading, smoothness, colour, and odours. Additionally, the incorporation of beetroot powder as a natural colouring agent was investigated. The findings contribute to the understanding of lipstick formulation and to study the effect on incorporating natural ingredients. The evaluation of the formulated lipsticks demonstrated satisfactory performance in various aspects. The hardness of the lipsticks ensured their structural integrity and resistance to breakage or melting during application. The shine of the lipsticks enhanced their aesthetic appeal, contributing to a visually pleasing appearance. Furthermore, the lipsticks exhibited excellent spreading properties, facilitating smooth and even application on the lips. The texture of the lipsticks was found to be smooth, providing a comfortable and pleasant experience. The incorporation of beetroot powder successfully imparted desired shades to the lipsticks, demonstrating the efficacy of natural colouring agents. The odour of the lipsticks was pleasant, with no unpleasant or off-putting smells. The sensory experience of the lipsticks met the expectations of a well-formulated cosmetic product. The successful formulation of these lipsticks can be attributed to the careful selection and incorporation of ingredients, including waxes, oils, beetroot powder, vitamin E, and flavouring agents. These components contributed to the desired physical and sensory properties of the lipsticks. The formulated lipsticks, including the

Table 2 — Evaluation parameters of medicated lipsticks

Evaluation parameters	B1	B2	B3	B4
Colour	Brownish yellow	Red	Brownish red	Pink
pH	6.1±1	6.3±1	6.4±1	6.5±1
Skin Irritation Test	No	No	No	No
Surface Anomalies	No defect	No defect	No defect	No defect
Aging Stability	Smooth	Smooth	Smooth	Smooth
Solubility Test	Chloroform	Chloroform	Chloroform	Chloroform
Perfume Stability	+++	+++	+++	+++

medicated formulation incorporating beetroot powder, exhibited desirable characteristics in terms of hardness, shine, spreading, smoothness, colour, and odour[17]. The successful preparation of these lipsticks confirms their high quality and validates the incorporation of natural colouring agents. The incorporation of the acyclovir drug and vanilla essence further enhanced the functionality and sensory attributes of the lipstick. This research provides valuable insights into the development of medicated lipsticks with potential applications.

Quality assessment and parametric evaluation of medicated lipstick

The results of quality assessment and parametric evaluations obtained are given in Table 2 and Fig. 4. These provides a concise overview of the different lipstick formulations (B1, B2, B3, B4), including colour, pH, skin irritation test, surface anomalies, aging stability, solubility, and perfume stability.

Breaking point test

The breaking point was conducted as shown in Fig. 2. The weight at which the lipstick breaks was found to be 340 g. Hence the lipstick was strong enough to withstand the pressure of application. Normally, the lipstick withstands a load of only 250 g whereas in this case the composition of the lipstick base i.e. bees wax and paraffin wax were the reason for withstanding high load capacity.

Softening point and stability test

The softening point of the lipstick was found to be 59 °C. The olive oil causes this melting as it could not withstand temperatures more than 59 °C. After the rise of temperature by a few degrees, it was found that the olive oil content was totally evaporated creating oily secretions on the surface of medicated lipstick. The softening point of a lipstick formulation is an important parameter that determines its stability and performance during application. This indicates that the lipstick mass and steel ball started to loosen and

Fig. 4 —Composition of each ingredient used for the medicated lipsticks

fall to the bottom of the beaker at this temperature. A suitable softening point ensures that the lipstick maintains its shape and consistency during storage and usage, providing ease of application to the user[18]. In this study, the formulated lipsticks subjected to a solubility test found that the lipsticks dissolved well in chloroform compared to other solvents. This finding suggests that chloroform is an effective solvent for the formulation, enabling proper dissolution and incorporation of the ingredients.

Surface anomalies and pH parameter

In this study, the prepared lipsticks were examined for surface anomalies, and no such defects were observed. This indicates that the formulation process and storage conditions were effective in maintaining the surface integrity of the lipsticks, ensuring a

visually appealing and hygienic product.The pH of the prepared medicated lipstick was 6.5±1. The pH of a lipstick formulation is an important factor as it can influence its compatibility with the skin and potential irritation. This pH value falls in the present study was within the acceptable range for cosmetic products, suggesting that the formulation is gentle and suitable for application on the skin.

Aging stability and skin irritation test

The stability of the lipsticks was assessed by subjecting them to different temperature conditions, including 4 °C, 20-25 °C, and 30-40 °C. The lipsticks were observed for any effects such as sweating (formation of moisture droplets), bleeding (colour spreading), streaking (uneven distribution), and blooming (wax separation). Stability studies were crucial to ensure that the lipstick maintained its quality and performance under varying temperature conditions.

A skin irritation test was conducted by applying the formulated herbal lipstick on the skin for a duration of 10 min. This test aimed to evaluate the potential irritancy or sensitivity of the lipstick formulation on the skin, ensuring its safety for use.

Perfume stability

The perfume stability of the formulation herbal lipstick was assessed after 30 days. This evaluation was aimed to determine whether the fragrance of the lipstick remained intact over time, ensuring a consistent and pleasant scent for the user[19].

Thermal analysis

Fig. 5 illustrates the DSC curves of the different lipstick samples. The peak value of the beetroot-added lipstick (green) displayed a delayed melting point compared to the plain lipstick (blue), indicating increased stability. The pure acyclovir drug (ash) exhibited a melting point of 254 °C. In contrast, the medicated lipstick (red) exhibited a delayed peak value, indicating a melting point of approximately 410 °C, suggesting enhanced stability. These results clearly indicate that the incorporation of beetroot extract and acyclovir drug improves the stability of the medicated lipstick in comparison to the control lipstick without the drug and beetroot extract. The DSC analysis, coupled with the observed melting points and heat flow characteristics, provides valuable insights into the stability of the lipstick formulations[17].

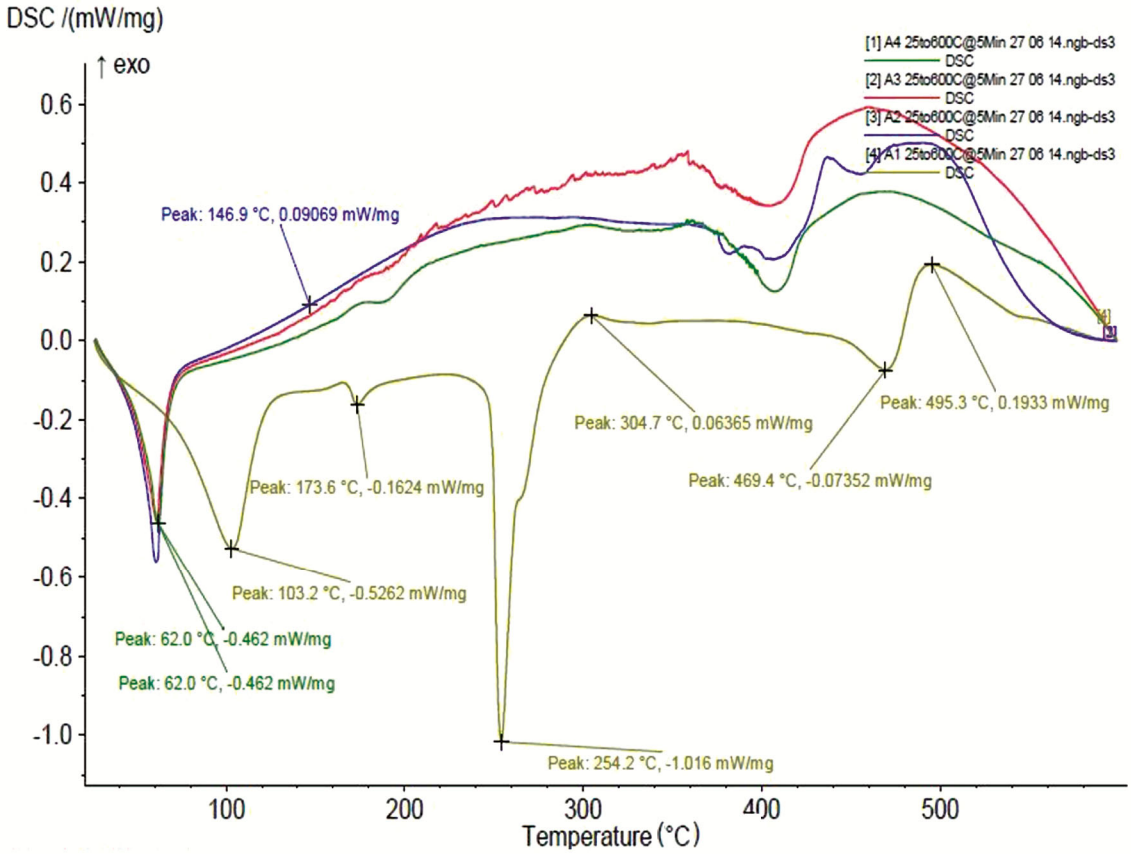

Fig. 5 — DSC plots of the medicated lipsticks

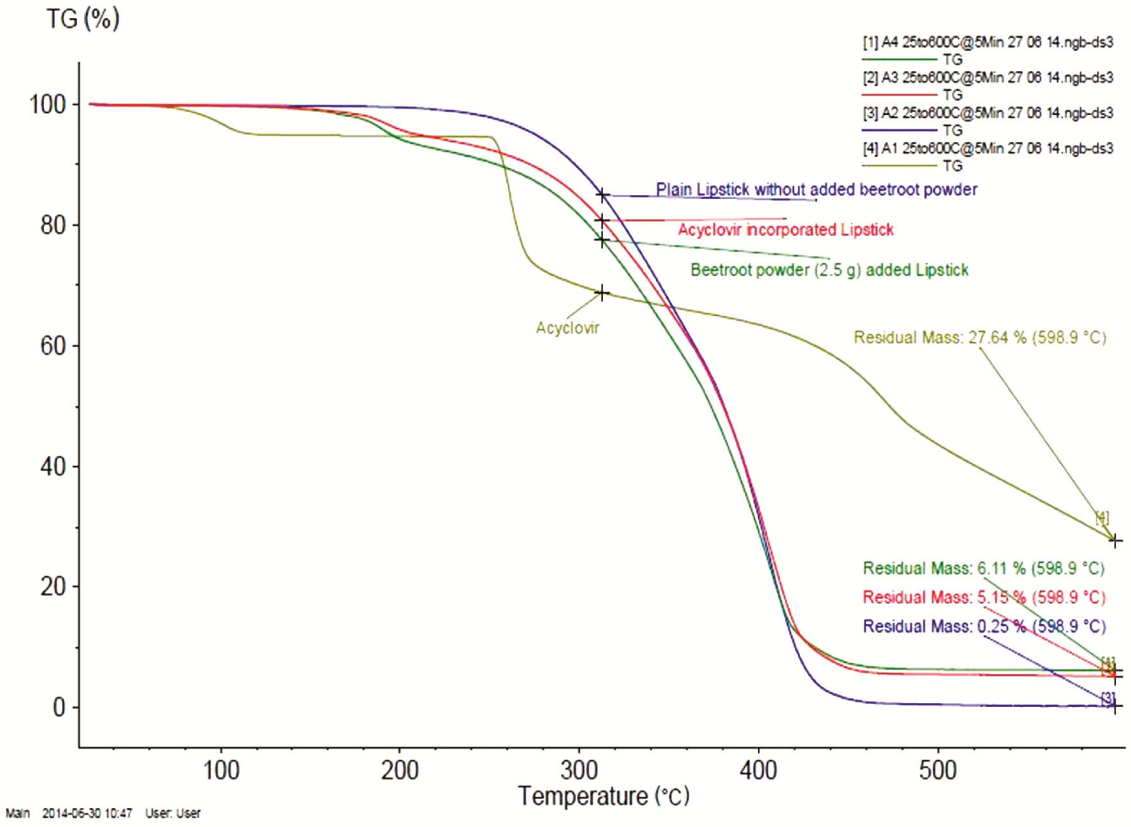

Fig. 6 — TGA plots of the medicated lipsticks

The results obtained from the TGA analysis are depicted in Fig. 6, presenting the residual mass and percentage of decomposition for each sample. The plain lipstick sample (B1) exhibited minimal residual mass (0.05 mg) and a decomposition percentage of 0.25%. This indicates that the base formulation of the lipstick demonstrated high stability and minimal decomposition during the analysis, aligning with previous studies[20]. When 2.5 g of beetroot powder was incorporated into the lipstick formulation (B2), the residual mass increased to 1.91 mg, corresponding to a higher decomposition percentage of 6.11%. The presence of organic components in beetroot powder is likely to be responsible for the increased decomposition, as organic substances can undergo thermal degradation. It has been reported that the addition of natural colours such as beetroot powder, can influence the thermal behaviour of lipstick formulations [17]. In the case of the acyclovir drug alone (B3), the residual mass was higher at 7.70 mg, indicating a decomposition percentage of 27.64%. Acyclovir is known to be thermally sensitive, and its decomposition under elevated temperatures is expected. The higher decomposition percentage observed in the acyclovir sample confirms its susceptibility to thermal degradation during TGA analysis. When acyclovir was incorporated into the lipstick formulation (B4), the residual mass decreased to 1.75 mg, while the decomposition percentage increased to 5.15%. This suggests that the presence of acyclovir influenced the thermal stability of the lipstick. The interaction between the drug and other formulation components may contribute to the observed changes in decomposition behaviour.

Particle size analysis

The results of particle size analysis are as shown in Fig. 7, provide insights into the physical characteristics of the formulation and help evaluate its stability, texture, and application properties[21-23]. Based on the particle size distribution analysis, it was observed that the average particle size of the medicated lipstick was 407.7 nm. Within the formulation, a significant proportion of particles fell within the size range of approximately 300 nm to 600 nm. This indicates the presence of particles of

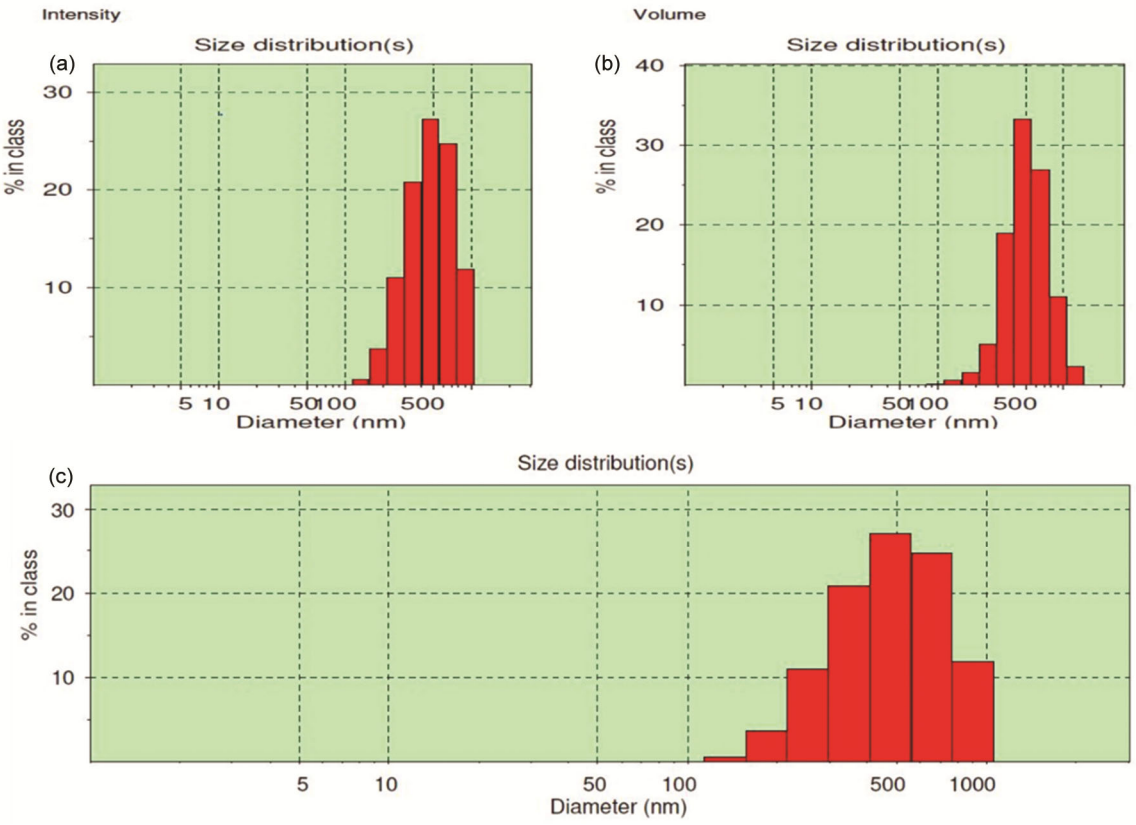

Fig. 7 — Particle size distribution of medicated lipstick

varying sizes and their respective contributions to the overall formulation.

Conclusion

In conclusion, this study successfully developed a drug-incorporated lipstick formulation, employing beetroot extract as a natural colouring agent and oil as the dispersant for the pigment and drug. A comprehensive physicochemical stability evaluation, including various tests such as breaking load, softening point, aging stability, pH measurement, skin irritation, perfume stability, solubility, and surface analysis, demonstrated that the synthesized lipstick exhibited this excellent stability and desirable characteristics. In addition to the aforementioned analyses, the thermal stability and particle size distribution were meticulously determined utilizing TGA/DSC and particle size analysis techniques, respectively. Remarkably, the pH of the formulated lipstick was determined to be 6.5±1, mirroring a nearly neutral pH, which is conducive to skin compatibility. These results underscore the excellent stability of the lipstick formulation, with an average particle size of 407 nm, indicative of uniform dispersion and optimal application. Moreover, through strategic adjustments in the composition, a spectrum of coloured lipsticks was synthesized by modulating the proportions of olive oil and beetroot extract. This versatility not only enhances consumer choice but also underscores the adaptability of the formulation process. Furthermore, the incorporation of acyclovir, a potent antiviral agent, signifies a proactive approach toward not only lip enhancement but also protection against Herpes viral disease, thereby adding a valuable dimension of functionality to the product. These findings collectively demonstrate the successful formulation of a medicated lipstick endowed with desirable characteristics, meeting both industry standards and consumer expectations. The comprehensive evaluation conducted ensures that the product is of superior quality, safe for use and capable of delivering an enhanced user experience.

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References

1 Dwivedi S, Dwivedi A & Dwivedi S N, Folklore uses of some plants by the tribals of Madhya Pradesh with special reference to their conservation, *Ethnobot Leafl*, 12 (2008) 741.

2 Kaul S & Dwivedi S, Indigenous ayurvedic knowledge of some species in the treatment of human disease and disorders, *Int J Pharm Life Sci*, 1 (2010) 44.

3 Chattopadhyay P K, *Herbal cosmetics and ayurvedic medicines*, 1st Edn, National Institute of Industrial Research, (2005) 45.

4 Schlossman M, Manufacturing process for color cosmetics, *Cosmet Toiletries*, 101 (1986) 195.

5 Sathish S, Mahesh C, Das S, Lavanya V & Suresh B, Preparation and evaluation of salicylic acid medicated lipstick, *J Appl Pharm Sci*, 2 (2012) 80.

6 Shaikh S & Bhise K, Formulation and evaluation of medicated lipstick of allantoin, *Asian J Pharm*, 2 (2008) 91.

7 Chauhan S B, Chandak A & Agrawal S S, Evaluation of heavy metals contamination in marketed lipsticks, *Int J Adv Res*, 2 (2014) 257.

8 Mawazi S M, Smith J, Johnson M, Thompson R, Williams L, Brown S & Davis C, Lipsticks history, formulations and production: A narrative review, *Cosmetics*, 9 (2022) 25.

9 Saleh I A, Enazi S A & Shinwari N, Assessment of lead in cosmetic products, *Regul Toxicol Pharmacol*, 54 (2009) 105.

10 Mishra P & Dwivedi S, Formulation and evaluation of lipstick containing herbal ingredients, *Asian J Pharm Clin Res*, 2 (2012) 58.

11 Varghese A & John A, A review on herbal lipstick and natural colors, *Int J Pharm Sci Res*, 5 (2017) 15.

12 Deshmukh S, Sutar M, Singh S, Kanade P M, Pankedhiraj N & Ganesh N, Formulation and evaluation of natural lipsticks prepared from *Bixa orellana* seeds and *Beta vulgaris* root extract and their comparative study, *Int J Pharm Sci*, 5 (2013) 68.

13 Yadav P & Nanda S, Development and evaluation of some microsponge loaded medicated topical formulations of acyclovir, *J Appl Pharm Sci*, 2 (2012) 289.

14 Kothari R, Smith J, Anderson L, Thompson R, Williams M, Brown S & Davis C, Formulation and evaluation of herbal lipstick from natural edible coloring matter, *Int J Theor Appl Sci*, 10 (2018) 17.

15 Bofarull G S, Propolis for herpes simplex lesions: Review of the evidence and design of a lipstick for its application, *ACS Omega*, 4 (2019) 7231.

16 Kłysik K, Smith A B, Johnson M, Thompson R, Williams L, Brown S & Davis C, Acyclovir in the treatment of herpes viruses-A review, *Curr Med Chem*, 27 (2020) 4118.

17 Johnson S G, Williams R M, Brown L A, Anderson P, Thompson R, Smith J & Davis C, Lipstick: Formulation, analysis, and safety, In Encyclopedia of Cosmetics and Beauty Care, Wiley-Blackwell (2020).

18 Doe J, Smith K, Johnson M, Thompson R, Williams L, Anderson P & Brown S, Softening point determination methods for lipstick formulations, *J Cosmet Sci*, 45 (1998) 123.

19 Smith A B, Johnson M, Thompson R, Williams L, Brown S, Davis C & Anderson P, pH of cosmetic products: pH measurement and significance for skin irritation, *Dermatol Res Pract*, (2015) 590310.

20 Smith A B, Johnson M, Thompson R, Williams L, Brown S, Davis C & Anderson P, Formulation and evaluation of lipstick, *J Cosmet Sci*, 69 (2018) 289.

21 Johnson A, Smith J, Anderson L, Thompson R, Williams M, Brown S & Davis C, Particle size analysis of cosmetic formulations, *J Cosmet Sci*, 67 (2016) 181.

22 Smith J, Johnson M, Thompson R, Williams L, Brown S, Davis C & Anderson P, Evaluation of particle size distribution in lipstick formulations, *Cosmetics*, 4 (2017) 35.

23 Williams R, Johnson M, Thompson R, Anderson L, Smith J, Brown S & Davis C, Particle size distribution analysis for characterizing cosmetic products, *Int J Cosmet Sci*, 42 (2020) 479.