Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 11s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Aloe Vera and Pear Extract Serum: A Herbal Approach to Intertrigo Management

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Cite this paper as: Lima Patel, Puja Bhavsar, Kinjal Bera, Avani Khristi, Khyati Patel, Pankhita Rede, Kripa Patel, Dhwani Patel, Vinay Jangir, (2025) Aloe Vera and Pear Extract Serum: A Herbal Approach to Intertrigo Management. *Journal of Neonatal Surgery*, 14 (11s), 1051-1059.

ABSTRACT

Background: Intertrigo is an inflammatory skin condition that occurs in newborns, infants and adults, typically affecting skin folds (flexural areas) such as the neck, armpits, groin, and under the chin. It results from a combination of moisture, friction, and microbial overgrowth, leading to redness, irritation, and maceration of the skin. Conventional treatments primarily focus on symptom management, highlighting the need for safer, plant-based alternatives. This study aimed to develop and validate a novel herbal serum containing Aloe vera (*Aloe barbadensis*) and pear (*Pyrus communis*) extracts for intertrigo treatment, with an emphasis on formulation optimization and analytical method validation.

Methods: The formulation was developed using Carbopol as a gelling agent to ensure optimal viscosity and stability. High-Performance Thin-Layer Chromatography (HPTLC) was employed for qualitative and quantitative analysis of Aloe emodin (Aloe vera) and Oleanolic acid (pear extract). Analytical method validation was performed following ICH Q2(R1) guidelines, evaluating parameters such as linearity, precision, accuracy, robustness, limit of detection (LOD), and limit of quantification (LOQ).

Results: The formulated serum exhibited excellent spreadability, pH compatibility, and homogeneity. HPTLC analysis demonstrated well-defined bands for Aloe emodin and Oleanolic acid at optimized Rf values. The method showed linearity (500–1500 ng/spot, $R^2 > 0.999$), precision (%RSD < 2%), and accuracy (98–102% recovery). The established LOD and LOQ values confirmed high sensitivity, ensuring reliable quantification of the bioactive markers. Robustness studies demonstrated the stability of the analytical method under minor variations.

Conclusion: The developed herbal serum demonstrated promising physicochemical properties and stability, while the validated HPTLC method provided accurate and reproducible quantification of Aloe emodin and Oleanolic acid. These findings support the potential of this novel herbal formulation as a natural therapeutic option for intertrigo.

Keywords: *Intertrigo, Aloe vera, Pear extract, Herbal serum, HPTLC, Analytical validation, Oleanolic acid, Aloe emodin.*

1. INTRODUCTION

Intertrigo is a superficial inflammatory condition affecting the skin's flexural surfaces, often triggered or exacerbated by factors such as elevated temperatures, friction, moisture, maceration, and inadequate ventilation. It results from a combination of moisture, friction, and microbial overgrowth, leading to redness, irritation, and maceration of the skin. In severe cases, secondary bacterial or fungal infections (e.g., Candida overgrowth) can develop, exacerbating the condition. This condition can manifest in individuals of all ages, but neonates and infants are particularly susceptible due to their delicate skin, excess moisture retention, limited airflow to skin folds, frequent diaper use, and an immature immune system and is generally diagnosed based on clinical presentation. Commonly affected areas include the axillae, inframammary creases, abdominal folds, and the perineum, typically appearing as a reddish rash. Excessive moisture, usually resulting from perspiration, causes skin surfaces to stick together in skin folds. This trapped moisture heightens friction, leading to skin damage and inflammation. In numerous cases, skin damage facilitates the overgrowth of bacteria and/or fungi that are normally present on the skin. The combination of warmth, moisture, and friction-induced skin damage creates an optimal environment for microbial proliferation. This microbial growth often causes secondary infections, worsening the inflammation and visible rash.[1]

To manage intertrigo and support skin healing, the use of targeted skincare products such as serums can be beneficial. Management typically involves keeping affected areas dry, using absorbent powders, applying barrier creams, and, in cases

of secondary infection, administering antifungal or antibacterial treatments. Serums penetrate deep into the skin and deliver active ingredients that help soothe and repair damaged skin. These lightweight, non-greasy formulas can be designed to provide intense nourishment and hydration, which can help restore the skin's natural barrier, reducing moisture build up and further friction. By addressing both hydration and microbial growth, herbal serums can offer therapeutic benefits for conditions like intertrigo while promoting overall skin health.[2,3,4] The selection of plants for the formulation of a novel herbal serum for intertrigo focuses on two key botanicals: Aloe vera and pear (*Pyrus communis*), chosen for their unique therapeutic properties and chemical profiles.

Aloe vera, also known as *Aloe or Kumari*, is derived from the dried juice of the leaves of *Aloe barbadensis miller* and belongs to the family Asphodelaceae (Liliaceae). It is rich in active compounds such as aloe emodin, aloin A and B, anthranol, aloesone, and chrysophanic acid. It is renowned for its moisturizing, soothing, and wound-healing properties, making it ideal for treating skin conditions like intertrigo. Aloe's antibacterial and antiviral effects, combined with its ability to stimulate macrophages, help in managing secondary infections while providing a soothing effect on irritated skin. This makes it a popular ingredient in various skin and hair care products like creams, shampoos, and moisturizers.[5,6,7]

Pear (*Pyrus communis*), also known as *Nash Pati*, comes from the fruit of this cultivated plant, which belongs to the Rosaceae family. It contains a range of beneficial compounds, including arbutin, gallic acid, ferulic acid, oleanolic acid, ursolic acid, chlorogenic acid and rutin, known for their anti-inflammatory, antimicrobial, and antioxidant properties. Pear extract contributes to the serum by supporting wound healing and by providing antimicrobial activity. These attributes make it an excellent addition to an herbal serum for conditions like intertrigo, where both infection control and skin repair are critical.[8,9]

Together, Aloe vera and pear extract work synergistically to provide moisture, fight infection, and enhance skin healing, making them highly suitable for inclusion in a herbal serum for intertrigo treatment

Oleanolic acid, present in pear, and Aloe emodin, present in Aloe vera, are important biomarkers for evaluating the quality of plant extracts intended for treating intertrigo. Oleanolic acid is valued for its antimicrobial and anti-inflammatory properties, which help address the infections and inflammation associated with intertrigo.[10,11,12,13] Aloe emodin, on the other hand, offers antibacterial and soothing effects that alleviate discomfort and promote healing in affected skin areas.[14] Together, Aloe vera and pear extract work synergistically to provide moisture, fight infection, and enhance skin healing, making them highly suitable for inclusion in a herbal serum designed specifically for intertrigo treatment.

2. MATERIALS AND METHODS

Oleanolic acid and Aloe emodin were sourced from Yucca Enterprises, while aloe vera extract was procured from Rutvik Enterprises. Pear were obtained from the local market.

Identification of markers

Identification of purchased phytomarkers was performed by following techniques by melting Point Determination and IR Spectroscopy.

Melting point

Identification by Melting point was confirmed by comparing the practically observed melting point of given sample with melting point reported in literature.

Infrared spectroscopy

Identification by IR spectroscopy was confirmed by comparing the practically obtained valleys (wave number) in IR spectra and Functional groups present in given sample molecules as well as comparing the obtained spectra with IR spectra recorded in Literature. IR Spectroscopy study was performed by preparing pellets of phytomarkers and KBr using pellet press technique at a pressure of 7-10 tones and FT-IR was scanned from 4000cm^{-1}-200 cm^{-1}.

Preparation of extract and sample solution

5.225 g of Aloe vera extract was weighed and transferred to 25 ml volumetric flask. Methanol was added to the weighed sample in a flask to prepare a sample solution. The solution was shaken frequently for 2 to 4 hours and allowed to stand in the dark for 24 hours. After 24 hours, the solution was strained and the filtrate was collected.

A fresh pear fruit was weighed, washed thoroughly with water, and peeled. The peel was collected in a clean petri plate. The crushed peel was extracted using an ethanol:water (80:20) ratio. The extract was left for 24 hours, then filtered using a muslin cloth, and the filtrate was collected and used for Analytical and formulation development.

HPTLC method development and validation

Preparation of standard solution of Aloe emodin and Oleanolic acid

10 mg of Aloe emodin and 10 mg of Oleanolic acid were individually weighed and transferred to separate 10 ml volumetric flasks. The volume in each flask was adjusted to the mark with methanol to prepare a 1000 µg/ml solution.

Visualization

The plate was observed in UV chamber (short wave 254 nm) for aloe emodien and then sprayed with anisaldehyde-sulphuric acid reagent and heated at 100^0C for 5 minutes till the colored bands appear for Oleanolic acid.

Instrumentation

A CAMAG HPTLC system (Muttenz, Switzerland) with a twin-trough developing chamber (10 × 10 cm), CAMAG Linomat V sample applicator, CAMAG TLC Scanner IV, and CAMAG TLC visualize along with UV cabinet with a dual-wavelength UV lamp and CAMAG winCATS software was used in the present study. Microsoft Excel 2019 was used to make the calculations for the quantification of extracts and the assessment of validation parameters.

Chromatographic conditions

The samples were spotted using a 100 µl syringe (Linomat syringe) and a CAMAG Linomat Vsample applicator in the current of nitrogen stream, on a pre-coated silica gel aluminium HPTLC plate 60 F254 (20 × 10 cm, 100mthickness, E. Merck, Darmstadt, Germany). Upon drying, the plates were subjected to densitometric scanning with a scanning speed of 20 mm/s, slit dimensions of 5 × 0.20 mm, and data resolution of 100 µm/step using absorbance–reflectance mode at 428 and 674 nm using a deuterium lamp and halogen tungsten lamp respectively. The findings were examined in order to acquire the best separation between spots and to assure separation reproducibility.

Preparation of mobile phase:

The mobile phase was prepared by combining Toluene and Methanol in a ratio of 9.5:0.5, with a total volume of 20 ml. First, 19 ml of Toluene was measured and transferred to a clean, dry container. Then, 1 ml of Methanol was measured and added to the container with Toluene. The components were thoroughly mixed to ensure a homogeneous solution and transferred to HPTLC mobile phase chamber. This solution was used as a mobile phase. The mobile phase chamber was kept aside for saturation with mobile phase for 20 minutes.

Method Validation

The method was validated in accordance with the ICH Q2 (R1) guideline to determine validation parameters such as linearity, precision, accuracy, limit of detection (LOD), limit of quantitation (LOQ), and robustness. Linearity was evaluated by spotting different concentrations of the standard on the plate. Precision was assessed through repeatability, intraday, and interday precision studies.[15] Repeatability was performed by conducting six consecutive determinations of a fixed concentration of Aloe emodin and Oleanolic acid. Intraday precision was evaluated by analyzing three different concentrations of Aloe emodin and Oleanolic acid at different time intervals on the same day. Interday precision was assessed by analyzing different concentrations of Aloe emodin and Oleanolic acid over multiple days.

Accuracy was determined using the recovery method. Triplicate samples were prepared, and accuracy was calculated by the standard addition method. This involved spiking a known amount of the standard into pre-analyzed sample solutions and determining the percentage recovery. Robustness was evaluated by deliberately making minor variations to multiple method parameters. The robustness of the method was assessed by altering factors such as wavelength and chamber saturation time. System Suitability Testing (SST) was performed to confirm the method's suitability for its intended use on the day of analysis. This is a crucial factor in ensuring the accuracy of the measurement process. SST was conducted by analyzing a freshly prepared stock solution and then evaluating six solutions of the same concentration. LOD and LOQ were determined by calculating the standard deviation of the slope obtained from the analysis of an appropriate number of analytical samples and their respective standard deviations.

Formulation Development

The formulation was developed using Carbopol as the gelling agent to achieve the desired viscosity and application properties. The process began with hydration, where Carbopol was dispersed in distilled water under continuous stirring to prevent clumping. Once the optimal consistency was achieved, Aloe emodin, Oleanolic acid, and other excipients were incorporated while maintaining uniform dispersion. The pH was adjusted for skin compatibility, and necessary preservatives or stabilizers were added.

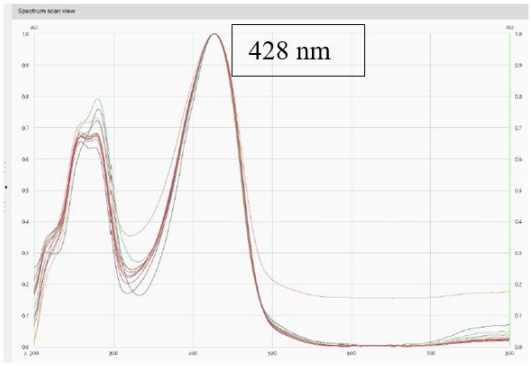
The formulation was evaluated for physical appearance, viscosity, pH, spreadability, and homogeneity to ensure stability and effectiveness. Viscosity was measured using a Brookfield Viscometer, and spreadability was tested for ease of application. Spreadability refers to how well the serum spreads on the skin or affected area. The test involved placing filter paper on a flat aluminum foil sheet without any folds or creases. The filter paper was carefully weighed before application. A precise amount of the formulation (20 drops) was applied to the center of the filter paper using a syringe. The liquid was allowed to spread for exactly 10 minutes, after which the saturated portion was carefully cut along the boundary between the wet and dry areas. The remaining dry filter paper was weighed, and the spread area was measured to assess the formulation's distribution properties. The formulation's uniform distribution of active ingredients was confirmed through visual inspection and tactile assessment, ensuring even consistency and stability. The overall evaluation confirmed that the Carbopol-based

formulation met the required parameters for viscosity, spreadability, pH, and homogeneity, ensuring stability and ease of application.

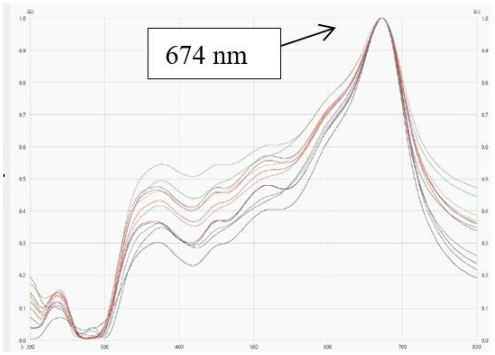
3. RESULTS AND DISCUSSION

Optimization of detection wavelength and mobile phase

The optimization of the HPTLC method involved systematic trials to refine mobile phase composition, detection wavelength, sample preparation, and chromatographic conditions. To achieve efficient separation of Aloe emodin and Oleanolic acid, multiple TLC trials were conducted using different solvent combinations. Various ratios of toluene, methanol, chloroform, and ethyl acetate were tested to identify the best mobile phase. Initial trials resulted in poor resolution, tailing, or minimal differences in Rf values. However, the mobile phase **Toluene: Methanol (9.5:0.5)** provided well-defined, sharp spots with minimal interference, making it the optimal choice for the analysis.



Densitometric UV spectra of Aloe emodin



Densitometric UV spectra of oleanolic acid after derivatization

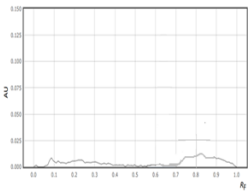
1 Demsitometric UV spectra of markers

Table 2 Optimized Chromatographic conditions

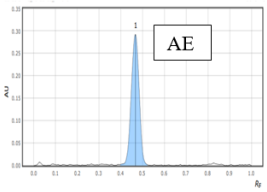
Sr. No.	Parameters	Chromatographic conditions
1	Stationary Phase	Aluminium Plate Pre-coated with Silica Gel 60 F254
2	Mobile Phase	Toluene: Methanol (9:1)
3	Chamber Saturation Time	20 min
4	Temperature	Room Temperature
5	Migration Distance	80 mm
6	Drying time	5 min
7	Derivatizing agent	Anisaldehyde-sulfuric acid reagent

1. Densitometric spectra of selected markers

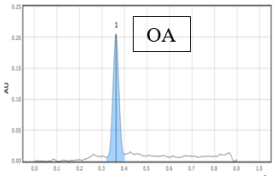
For accurate quantification, the detection wavelength was carefully optimized. The densitometric UV spectra of Aloe emodin and Oleanolic acid were recorded in the range of 200–800 nm using a CAMAG TLC scanner. The maximum absorbance was observed at 428 nm for Aloe emodin and 674 nm for Oleanolic acid, after derivatization with anisaldehyde-sulfuric acid. The detection wavelengths were selected based on peak intensity, resolution, and minimal matrix interference.



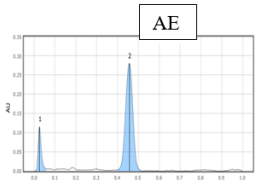
Densitogram of Methanol

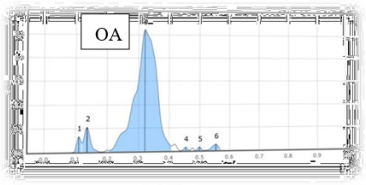


Densitogram of Aloe emodin



Densitogram of Oleanolic acid





Densitogram of mixture of extract

2. **Densitograms of solvent, markers and extracts**

Method validation

Specificity

The method's specificity was evaluated by analyzing standard drugs and samples in the presence of other components. The technique successfully resolved the peaks of Aloe emodin and Oleanolic acid without interference, demonstrating its selectivity. The densitograms confirmed the absence of overlapping peaks, establishing that the method is suitable for identifying and quantifying these phytomarkers in complex matrices.

Linearity and Range

The method exhibited a linear response for Aloe emodin and Oleanolic acid within the range of 500–1500 ng/spot. The calibration curves demonstrated excellent correlation coefficients (R^2 = 0.9998 for Aloe emodin and R^2 = 0.9995 for Oleanolic acid), indicating a strong linear relationship between concentration and peak area. This suggests the method's reliability for accurate quantification over the specified range.

Precision

Precision was assessed through repeatability, intraday, and interday studies. The repeatability test showed %RSD values of 0.6896 for both Aloe emodin and Oleanolic acid, well within the acceptance criteria (%RSD < 2).

For intraday precision, %RSD values ranged from 0.3093 to 1.8450 across different concentrations, while interday precision studies yielded %RSD values between 0.5991 and 1.8162. The low %RSD values confirm the high reproducibility of the method, indicating minimal variation in analytical performance over time and across different runs.

Accuracy

The accuracy of the method was determined by recovery studies using the standard addition method. The percentage recovery values for Aloe emodin and Oleanolic acid fell within the acceptable range of 98% to 102%, confirming the method's accuracy in quantifying these compounds in the presence of matrix components.

Robustness

Method robustness was evaluated by introducing minor variations in key parameters, such as wavelength and chamber saturation time. The %RSD values for Aloe emodin and Oleanolic acid remained below 2.0, indicating that slight modifications in experimental conditions did not significantly affect the analytical performance, thus demonstrating the method's robustness.

System Suitability

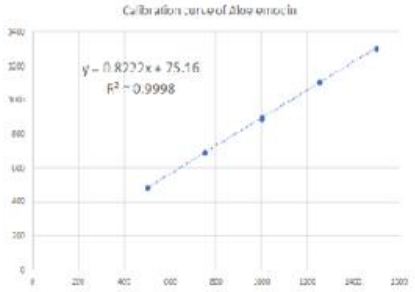
System suitability was assessed through the evaluation of Rf values and %RSD of retention factor measurements. The %RSD values of 0.60 and 0.57 for Aloe emodin and Oleanolic acid, respectively, were within the acceptance criteria. This confirms the system's consistency and reliability for routine analysis.

Limit of Detection (LOD) and Limit of Quantification (LOQ)

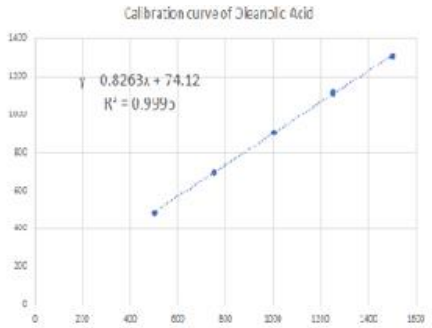
LOD and LOQ were determined using the standard deviation method. The LOD values were 60 ng/spot for Aloe emodin and 120 ng/spot for Oleanolic acid, whereas LOQ values were 120 ng/spot and 363 ng/spot, respectively. These values indicate the method's high sensitivity, allowing detection and quantification of low concentrations of the analytes.

Table 2 Validation parameters for developed method.

Sr. No.	Parameter	Aloe Emodin	Oleanolic Acid
1	Linearity	Area (Mean ±SD)	Area (Mean ±SD)
	500 ng/spot	463.4 ± 6.2	452.8 ± 6.2
	750 ng/spot	606 ± 7.5	616.6 ± 7.5
	1000 ng/spot	748.2 ± 8.1	772.2 ± 8.1
	1250 ng/spot	905.8 ± 9.0	909 ± 9.0
	1500 ng/spot	1015.2 ± 10.2	1010.6 ± 10.2
2	Range (ng/spot)	500 – 1500	500 – 1500
3	Correlation Coefficient (R^2)	0.9998	0.9995
4	Accuracy (% Recovery)	98 - 102%	98 - 102%
5	LOD (ng/spot)	60	181
6	LOQ (ng/spot)	120	363
7	Precision (%RSD)		
	Repeatability	0.6896	0.6896
	Intraday	0.52	1.54
	Interday	1	0.74
8	Robustness (% RSD)	0.23	0.78

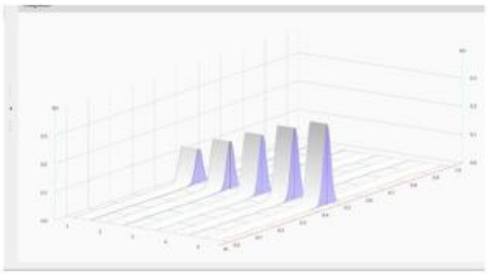


Calibration curve of Aloe emodin



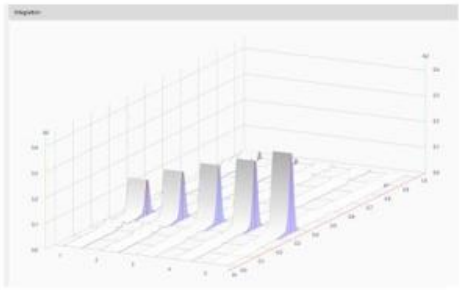
Calibration curve of Oleanolic acid

Linearity bands at 428 nm



3-D Chromatogram Aloe emodin at 428 nm

Linearity bands at 674 nm



3-D Chromatogram Oleanolic acid at 674 nm

3 Calibration curve and linearity bands of markers

Table 3 Estimation of Marker in Extract

Marker Compound	Source	Concentration in Extract (% w/V)
Aloe-emodin	Aloe Extract	**0.0052%**
Oleanolic Acid	Pear Pulp Extract	**0.0025%**

Formulation Development

The formulation development process involved multiple trials to adjust the viscosity of the serum. Various concentrations of Carbopol in different volumes of water were tested. Initial trials with 0.3 g of Carbopol in 8 ml and 12 ml of water resulted in a consistency that was too viscous for a serum. Similarly, trials with 0.2 g of Carbopol in 6 ml and 7 ml of water also produced a thicker consistency than desired. However, when 0.2 g of Carbopol was dispersed in 7.5 ml of water, the consistency improved but was still not as flowy as required for a serum. Finally, an ideal serum consistency was achieved with 0.2 g of Carbopol in 8 ml of water, establishing the optimal ratio of 0.2:8 (Carbopol: Water) for serum formulation. The formulation contained Aloe extract (4 g) for its soothing properties, Pear extract (0.3 g) as an antimicrobial agent, Carbopol 940 (0.2 g) as a viscosity enhancer, Vitamin E (0.1 ml) as an antioxidant, and water as a solvent, making up the total volume of 10 ml.

Table 4 Ingredients for formulation

Ingredients	Quantity	Purpose
Aloe extract	4 gm	Soothing
Pear extract	0.3 gm	Antimicrobial
Carbopol 940	0.2 gm	Viscosity enhancer
Vitamin E	0.1ml	Antioxidant
Water	q.s.	Solvent

The developed formulation was evaluated based on various parameters. The physical appearance was observed visually, and the serum was found to be a white, viscous liquid with a smooth, homogeneous texture and a glossy appearance. The viscosity, measured using a Brookfield viscometer with spindle 61 at 50 rpm, was recorded as 522.4 mPa.s, indicating suitable flow properties for a serum. The pH of the formulation, measured after dissolving 1 ml of serum in 50 ml of distilled water, was found to be 4.37, which aligns with the natural pH range of the skin (4–6), ensuring compatibility for topical application.

The spreadability of the serum was assessed using a filter paper method, where the percent spread by area was calculated as 62%, confirming good spreadability on the skin. The homogeneity of the formulation was evaluated by visual appearance and touch, demonstrating uniform distribution of extracts throughout the serum. The concentration of active markers in the final serum formulation was estimated to confirm their presence in the desired range. Aloe-emodin from aloe extract and oleanolic acid from pear pulp extract were quantified. Aloe-emodin was found to be 0.00208% w/v in serum, with a 98.09% label claim, while oleanolic acid was 0.000095% w/v, with a 95.00% label claim. These values indicate that the active components were retained effectively in the formulation within the acceptable range of 95-98%

Table 5 Estimation of marker in formulation

Marker Compound	Source	Concentration in Serum (% w/v)	% Label Claim
Aloe-emodin	Aloe Extract	**0.002080%**	**98.09%**
Oleanolic Acid	Pear Pulp Extract	**0.000095%**	**95.00%**

Table 6 Summary of evaluation parameters:

Sr. No.	Evaluation test	Result
1	Appearance	Clear
2	Viscosity	522.4 mPa.s
3	PH	4.37
4	Spread ability	62%
5	Homogeneity	Good

4. CONCLUSION

The study successfully developed and validated a method for formulation development, ensuring optimal viscosity, stability, and effectiveness. The trials conducted for viscosity adjustment demonstrated that a Carbopol-to-water ratio of 0.2:8 provided the ideal serum consistency. The formulated serum exhibited desirable physical characteristics, including smooth texture, good spreadability (62%), and suitable viscosity (522.4 mPa.s). Additionally, the pH (4.37) was well within the acceptable range for skin application, ensuring compatibility and safety. The comprehensive evaluation confirmed the homogeneity of the formulation, ensuring uniform distribution of active ingredients. Additionally, the estimation of marker compounds confirmed the appropriate amount of active ingredients, with % label claims maintained between 95-98%, ensuring the serum's efficacy. This confirms that the formulation is well-designed for intended cosmetic application. The developed serum met all required parameters, making it a well-balanced formulation suitable for cosmetic or therapeutic applications. intertrigo is a frequent issue in neonates, a herbal serum with antimicrobial, anti-inflammatory, and wound-healing properties could be a safer and natural alternative to conventional treatments.

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