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DEVELOPMENT AND PHARMACEUTICAL EVALUATION OF COSMETIC SERUM AND TONER INCORPORATING PINEAPPLE PEEL EXTRACT

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ABSTRACT

The present investigation was carried out to formulate and pharmaceutically evaluate cosmetic face serum and toner containing pineapple peel extract as a natural, value-added bioactive ingredient. Pineapple peel, an abundant agro-industrial by-product, is known to contain biologically active constituents such as bromelain, phenolic compounds, antioxidants, and organic acids, which contribute to various dermatological benefits including exfoliation, antioxidant protection, and antimicrobial activity. Pineapple peel extracts were prepared using ethanolic solvents of two different strengths (30% and 70%) by the maceration method. The obtained extracts were incorporated into cosmetic formulations to develop four face toner formulations (F1–F4) containing varying concentrations of extract and preservatives, and one face serum formulation using 30% ethanolic extract as the active component. All prepared formulations were subjected to comprehensive evaluation for physicochemical characteristics such as appearance, pH, viscosity, surface tension, spreadability, stickiness, homogeneity, and stability under different

storage conditions. Safety assessment was performed through skin irritation studies, while microbial limit tests were conducted to ensure product quality. The results demonstrated that all formulations exhibited skin-friendly pH, acceptable viscosity, uniform consistency, and good spreadability. No phase separation, discoloration, or significant changes were observed during stability testing. Microbial analysis confirmed the absence of contamination, and skin irritation studies indicated that the formulations were non-irritant and safe for topical application. Among the developed products, the face serum showed enhanced spreadability and superior cosmetic acceptability. The study concludes that pineapple peel extract is a promising natural ingredient for cosmetic serum and toner formulations, offering effective skin benefits while supporting sustainable and eco-conscious product development.

KEYWORDS: Pineapple peel extract, Cosmeceutical formulation, Bromelain, Phenolic compounds, Natural antioxidants, Agro-waste utilization.

INTRODUCTION

In recent years, there has been a significant shift in consumer preference towards the use of natural and herbal products in cosmetic and personal care applications. This change is largely attributed to increasing awareness regarding the potential adverse effects associated with prolonged use of synthetic chemicals on the skin. Conventional cosmetic formulations often contain artificial preservatives, colorants, and surfactants that may cause skin irritation, hypersensitivity reactions, and long-term dermatological issues. As a result, there is a growing demand for safer, skin-friendly, and environmentally sustainable cosmetic products derived from natural sources. Cosmeceuticals, a rapidly expanding segment of the cosmetic industry, combine cosmetic properties with therapeutic benefits. These products are designed not only to enhance appearance but also to improve skin health by delivering biologically active ingredients. Among natural sources, fruits and plant-derived materials have gained considerable attention due to their rich content of antioxidants, enzymes, vitamins, and phenolic compounds. In recent pharmaceutical research, agro-industrial waste such as fruit peels has emerged as a valuable and sustainable source of bioactive constituents suitable for cosmetic formulation.

Fig. No: 01 Pineapple Peel.

Pineapple (Ananascomosus L. Merr.), belonging to the family Bromeliaceae, is a tropical fruit widely cultivated in countries such as India, Brazil, Thailand, and the Philippines. Traditionally known for its nutritional and medicinal value, pineapple has recently gained prominence in cosmeceutical applications. Pineapple contains bromelain, a proteolytic enzyme complex known for its exfoliating, anti-inflammatory, wound-healing, and antimicrobial properties. In addition to bromelain, pineapple is rich in vitamin C, polyphenols, flavonoids, organic acids, and essential minerals that contribute to skin rejuvenation, antioxidant protection, and improvement of skin texture. Pineapple peel (Fig: 01), which is generally discarded as waste, contains a higher concentration of phenolic compounds and antioxidants compared to the edible pulp. Several studies have reported that pineapple peel extract exhibits significant antioxidant, antimicrobial, and anti-inflammatory activities, making it a promising ingredient for topical cosmetic formulations. Utilization of pineapple peel extract not only enhances the therapeutic efficacy of cosmetic products but also promotes waste valorization and environmental sustainability.

Face toners and face serums play an important role in daily skincare routines. Face toners are used to cleanse pores, restore skin pH, tighten skin, and prepare the skin for subsequent cosmetic application. Face serums, on the other hand, are concentrated formulations designed to deliver active ingredients deep into the skin due to their low viscosity and enhanced penetration ability. Incorporation of natural extracts such as pineapple peel extract into these formulations can provide multiple benefits including gentle exfoliation, antioxidant protection, antimicrobial action, and skin brightening effects.

The use of herbal ingredients such as aloe vera, honey, green tea extract, and rose water in combination with pineapple peel extract offers synergistic benefits. Aloe vera is well known for its moisturizing, soothing, and wound-healing properties. Honey acts as a natural humectant with antibacterial and antioxidant activity. Green tea extract is rich in catechins

that provide anti-aging and photoprotective effects, while rose water contributes to skin soothing and toning action. The inclusion of these natural ingredients enhances the overall safety, efficacy, and consumer acceptability of the formulation. In view of the above considerations, the present study was undertaken to develop and evaluate cosmetic serum and toner formulations incorporating pineapple peel extract. The study focuses on the preparation of ethanolic extracts of pineapple peel using different solvent concentrations and their incorporation into topical cosmetic formulations. The prepared formulations were evaluated for various physical parameters, stability, skin irritation, and microbiological quality to assess their suitability for cosmetic application.

Rationale for Combined Use of Face Serum and Face Toner

The combined use of face toner and face serum offers a synergistic approach to skincare. Toners prepare the skin by cleansing pores and restoring pH, while serums deliver concentrated active ingredients into the skin layers. Incorporation of pineapple peel extract into both formulations ensures continuous delivery of antioxidant, anti-inflammatory, and exfoliating bioactives, enhancing overall skin health and cosmetic performance. The development of herbal face serum and toner using pineapple peel extract aligns with current trends in sustainable cosmeceutical research, offering effective skincare solutions while promoting utilization of natural resources and agro-waste materials.

MATERIALS AND INSTRUMENTS USED

All materials and chemicals used in the present study were of analytical or laboratory grade and were obtained from reliable sources to ensure quality and consistency. Honey, rose water, and green tea were used in the formulation. Fresh aloe vera leaves and pineapple peels were collected from the local market for extract preparation. Sodium benzoate was used as a preservative, Tween 20 was employed as a non-ionic surfactant, and ethanol was used as the extraction solvent. Sandalwood oil and rose oil were incorporated for fragrance and additional skin-beneficial properties. Formulation and evaluation were carried out using standard laboratory instruments. pH was measured using a digital pH meter. Surface tension and viscosity were determined using a stalagmometer and an Ostwald viscometer, respectively. All instruments were properly cleaned and calibrated prior to use to ensure accurate and reliable results.

EXTRACTION PROCESS

Fresh pineapple peels were procured and thoroughly cleansed with distilled water to remove adhering impurities. The cleaned peels were shade-dried at ambient temperature until a constant weight was obtained, ensuring complete removal of surface moisture. The dried material was then pulverized using a mechanical grinder to obtain a coarse powder. An accurately weighed quantity (10 g) of the powdered peel was used for extraction. Maceration was employed as the extraction technique using ethanol at two different concentrations (30% v/v and 70% v/v) in order to evaluate the effect of solvent polarity on the recovery of phytoconstituents. The weighed powder was transferred separately into two airtight containers containing the respective solvents and maintained at room temperature for 72 hours with occasional agitation to enhance solvent penetration and mass transfer. Upon completion of the extraction period, the mixtures were first passed through muslin cloth and subsequently filtered using Whatman filter paper to obtain clear filtrates. The resulting extracts were collected, transferred into airtight containers, and stored under refrigerated conditions until further formulation and analysis.(fig: 02)

Fig. No. 02: Extraction process.

Rationale for Selection of Ingredients with Their Functional Properties and Mechanism of Action. (Table: 01)

Table 01: Rationale for Selection of Ingredients with Their Functional Properties and Mechanism of Action.

S.NO	INGREDIENTS	PROPERTIES	MECHANISM
1	Pineapple Peel Extract 	Antioxidant, anti-inflammatory, rich in phenolic compounds, antimicrobial	Contains phenolic compounds and vitamins with antioxidant activity; bromelain enzymes exhibit anti-inflammatory and anticancer effects; protects cells from oxidative stress and inhibits microbial growth.
2	Honey 	Antibacterial, antioxidant, moisturizing, anti-inflammatory	High osmolarity and low pH inhibit microbial growth; produces hydrogen peroxide for antimicrobial effect; contains antioxidants that scavenge free radicals, reduce oxidative stress, and promote healing.
3	Aloe Vera 	Anti-inflammatory, antioxidant, moisturizing, collagen synthesis promotion, wound healing	Contains polysaccharides like acemannan that mediate anti-inflammatory and antioxidant action; promotes collagen synthesis and tissue repair; scavenges free radicals and reduces apoptosis in damaged skin.
4	Rose Water 	Antioxidant, anti-inflammatory, soothing, anti-aging, skin healing	Contains polyphenols, flavonoids, tannins that reduce inflammation and oxidative damage; soothes irritated skin, reduces redness, aids healing of cuts and scars.
5	Green Tea Extract 	Antioxidant, anti-aging, anti-inflammatory, photoprotective	Contains catechins and polyphenols that neutralize free radicals, reduce inflammation, and protect skin from environmental damage. Enhances anti-aging and protective effects of the formulation.
6	Tween 20 	Non-ionic surfactant, solubilizer	Helps solubilize essential oils in the aqueous phase of the serum, ensuring uniform dispersion, stability, and smooth application.
7	Essential Oils (Rose oil & Sandalwood oil)	Antimicrobial, soothing, aromatic, skin conditioning	Provide antimicrobial protection, soothing effect, and pleasant fragrance. Also contribute to skin calming and improve user acceptability of the serum.

			
8	Sodium Benzoate 	Antimicrobial preservative	Prevents microbial growth and enhances product stability by inhibiting bacteria, yeast, and molds, thereby increasing shelf life and safety of the toner formulations containing aqueous components.

PREPARATION OF FACE TONER

Four formulations of face toner (F1–F4) were prepared using pineapple peel extract obtained with two different ethanol concentrations (30% and 70%) (Table: 02). Each formulation was prepared for a batch size of 50 ml. Initially, the required quantity of aloe vera gel was weighed accurately and dispersed in a small portion of purified water with continuous stirring to obtain a uniform base. Honey was then added to the dispersion and mixed thoroughly until a homogeneous mixture was formed. Green tea extract and pineapple peel extract were incorporated slowly into the mixture with continuous stirring to ensure uniform distribution of the active constituents. In formulations requiring preservative, sodium benzoate was dissolved separately in a small quantity of purified water and added to the mixture. Rose water was added to impart toning and soothing properties. The volume of the formulation was adjusted to 50 ml using purified water and mixed continuously until a clear and homogeneous solution was obtained. The prepared toner formulations were transferred into clean, well-closed containers and stored at room temperature for further evaluation. (fig: 03 & 04)

FORMULATION TABLE FOR FACE TONER

Table 02: Four formulations of face toner (F1–F4).

INGREDIENTS \ FORMULATION CODE(FACE TONER - For 50 ml)	**F1** 30% Ethanol Extract Without Sodium Benzoate	**F2** 30% Ethanol Extract With Sodium Benzoate	**F3** 70% Ethanol Extract Without Sodium Benzoat	**F4** 70% Ethanol With Sodium Benzoate
Pineapple peel 30%ethanol extract	12.5ml	12.5ml	-	-

Pineapple peel 70 % extract	-	-	12.5ml	12.5ml
Sodium benzoate	-	0.2g	-	0.2g
Aloe Vera	2.5g	2.5g	2.5g	2.5g
Honey	1.5ml	1.5ml	1.5ml	1.5ml
Green tea extract	2.5ml	2.5ml	2.5ml	2.5ml
Rose water	5ml	5ml	5ml	5ml
Water	Q.S	Q.S	Q.S	Q.S

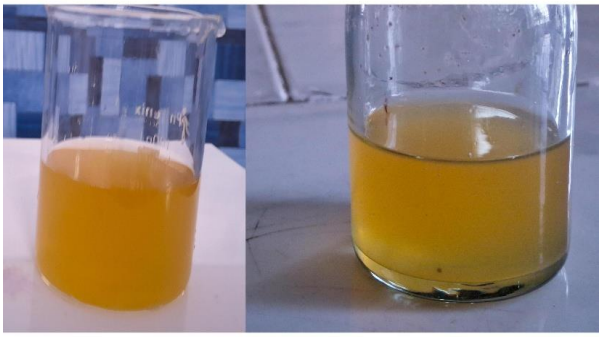

Fig. No. 03: 30% Ethanol Extract Without & with Sodium Benzoate.

Fig. No. 04: 70% Ethanol Extract Without & with Sodium Benzoate.

PREPARATION OF FACE SERUM

The face serum was prepared using pineapple peel extract obtained with 30% ethanol for a batch size of 50 ml (Table: 03). Aloe vera gel was taken as the base and stirred gently to obtain a smooth consistency. Honey was added to the base and mixed uniformly. Tween 20 was incorporated as a non-ionic surfactant to aid solubilization of essential oils. Pineapple peel extract was then added slowly under continuous stirring. Rose oil and sandalwood oil were added to the mixture and stirred thoroughly to ensure uniform dispersion. The final volume was adjusted waith purified water, and the formulation was mixed continuously until

a clear, smooth, and homogeneous serum was obtained. The prepared serum was filled into suitable containers and stored at room temperature for further evaluation. (fig: 05)

Formulation Table For Face Serum

Table 03: Face Serum Formulation tables.

INGREDIENTS (Face Serum For- 50 ml)	**QUANTITY REQUIRED**
Pineapple peel 30% ethanol extract	10ml
Aloe Vera	33.5 ml
Honey	1.6ml
Tween 20	1ml
Essential oil (rose oil+ sandalwood oil)	1.3ml + 1ml
Water	1.6ml

Fig No. 05: 30% Ethanol Extract Face serum.

EVALUATION PARAMETERS FOR FACE TONER AND FACE SERUM

- **pH Determination:** The pH of the formulations was measured using a calibrated digital pH meter. The instrument was standardized with buffer solutions of pH 4.0 and 7.0 before analysis. About 10 ml of each formulation was taken in a beaker, and the electrode was immersed into the sample. The pH reading was recorded after stabilization. The acceptable pH range for face toner was 5.5–7.0, while for face serum it was 4.5–6.5.

- **Surface Tension:** Surface tension of the formulations was determined using a stalagmometer by the drop count method. The number of drops of distilled water and formulation falling from the stalagmometer were counted separately, and the values obtained were compared with standard limits.

- **Stickiness Test:** A small quantity of the formulation was placed between two clean glass slides and gently pressed together. The slides were then separated and examined for stickiness. The formulation was considered acceptable if it exhibited minimal or no stickiness.

- **Viscosity Measurement:** Viscosity of the formulations was determined using an Ostwald viscometer at room temperature. The time required for the formulation to flow between two marked points was recorded and compared with distilled water. The acceptable viscosity range was 0.5–2.0 cp for face toner and 1.0–3.0 cp for face serum.

- **Spreadability (for Face Serum)**: A fixed quantity of serum was placed between two glass slides. A known weight was applied on the upper slide, and the time taken for the slides to separate was recorded. Good spreadability indicated ease of application.

- **Skin Irritation Test (Patch Test):** A small amount of formulation was applied to the skin and left undisturbed for 20 minutes. The application site was observed for redness, itching, swelling, burning sensation, or inflammation. Absence of such reactions indicated that the formulation was safe for topical use.

- **Light Exposure Test:** The formulations were stored in transparent containers and exposed to natural daylight for seven days. Any change in colour, clarity, or odour was observed.

- **Homogeneity:** The formulations were visually inspected and gently shaken to check uniform distribution of ingredients. Absence of lumps, particulate matter, or phase separation indicated good homogeneity.

- **Temperature Variation (Stability Study):** The formulations were stored under different temperature conditions and observed periodically for any physical changes such as colour change, viscosity variation, precipitation, or phase separation.

- **Microbial Growth Study:** A loopful of each formulation was streaked onto nutrient agar plates under aseptic conditions and incubated at 37°C for 24–48 hours. The plates were examined for microbial growth. Absence of visible colonies indicated good microbiological quality.

- **Washability (for Face Serum):** The applied serum was washed with running tap water, and ease of removal was observed. The formulation was considered acceptable if it was easily washable without leaving greasy or sticky residue.

RESULTS AND DISCUSSION

FOR FACE TONER: (Table: 04)

- **pH Determination:** The pH values of the developed face toner formulations (F1–F4) were found to be within the acceptable skin-compatible range of 5.5–7.0. Formulation F1 showed a pH of 6.80, F2 showed 6.70, F3 showed 6.86, and F4 showed 6.82. These results indicate that all formulations are suitable for topical application and are unlikely to disturb the natural pH of the skin.

- **Surface Tension:** The surface tension values of the toner formulations were found to range between 46.04 and 56.05 dynes/cm. Formulation F1 showed 51.77 dynes/cm, F2 showed 56.05 dynes/cm, F3 showed 46.04 dynes/cm, and F4 showed 51.50 dynes/cm. The obtained values fall within acceptable limits for cosmetic toners, indicating good wetting and spreading properties on the skin.

- **Stickiness Test:** All face toner formulations were found to be non-sticky when tested between glass slides. The absence of stickiness indicates good cosmetic acceptability and user comfort.

- **Viscosity Measurement:** The viscosity values of the toner formulations ranged between 0.62 and 1.55 cp. Formulatio F1 showed 0.62 cp, F2 showed 0.77 cp, F3 showed 1.17 cp, and F4 showed 1.55 cp. All values fall within the acceptable range of 0.5–2.0 cp, indicating appropriate flow characteristics for liquid toner formulations.

- **Skin Irritation Test (Patch Test):** Formulations F1 and F3 showed no signs of skin irritation, whereas mild irritation was observed with formulations F2 and F4. However, none of the formulations produced severe redness, itching, or inflammation, indicating overall safety for topical use.

- **Light Exposure Test:** All toner formulations remained stable after exposure to natural daylight for seven days. No change in colour, clarity, or odour was observed, indicating good photostability.

- **Homogeneity:** Visual inspection revealed that all toner formulations were clear and homogeneous with uniform distribution of ingredients and no visible particulate matter.

- **Temperature Variation (Stability Study):** All formulations remained stable under different temperature conditions. No precipitation, phase separation, or change in clarity was observed, indicating good physical stability.

- **Microbial Growth Study:** No microbial growth was observed in any of the toner formulations after incubation on nutrient agar plates. This indicates good microbiological quality and effectiveness of preservation.

Table 04: Results of Face toner.

Evaluation parameters (Face tonner)	**F1**	**F2**	**F3**	**F4**
pH measurement Range (5.5-7.0)	6.80	6.70	6.86	6.82
Surface tension (dynes/cm) Range (35-60 dynes/cm)	51.777	56.059	46.040	51.501
Stickness test	Non- sticky	Non- sticky	Non-stick	Non- sticky
Viscosity (cp) Range (0.5-2.0 cp)	0.6204	0.7714	1.17145	1.55035
Skin irritation	No Irritation	Mild Irritation	No Irritation	Mild Irritation
Light exposure test	Stable	Stable	Stable	Stable
Homogeneity	Clear and uniform	Clear and uniform	Clear and uniform	Clear and uniform
Spreadability	Good	Good	Good	Good
Temperature variation	Stable(no change)	Stable (no change)	Stable (no change)	Stable (no change)
Microbial Growth	Nill	Nill	Nill	Nill

FOR FACE SERUM (Table: 05)

- **pH Determination:** The pH of the face serum formulation was found to be 4.73, which falls within the acceptable range of 4.5–6.5. This pH is suitable for maintaining skin health and enhancing penetration of active ingredients.

- **Surface Tension:** The surface tension of the face serum was found to be 45.85 dynes/cm. This value indicates good wetting properties and ease of spreading on the skin.

- **Stickiness Test:** The face serum formulation exhibited non-sticky behaviour when tested between glass slides, indicating good cosmetic acceptability.

- **Viscosity Measurement:** The viscosity of the face serum was found to be 1.37 cp, which lies within the acceptable range of 1.0–3.0 cp. This indicates that the formulation possesses suitable consistency for easy application and retention on the skin.

- **Spreadability Test:** The face serum exhibited good spreadability with minimal resistance between glass slides, indicating ease of application over the skin surface.

- **Skin Irritation Test (Patch Test):** No signs of redness, itching, swelling, or irritation were observed at the application site. This confirms the safety of the serum formulation for topical use.

- **Light Exposure Test:** The face serum remained stable after exposure to natural daylight for seven days. No change in colour, clarity, or odour was observed.

- **Homogeneity:** The serum formulation was found to be clear, smooth, and homogeneous, with no evidence of lumps, grittiness, or phase separation.

- **Temperature Variation (Stability Study):** The serum remained physically stable under different temperature conditions, with no significant changes in colour, viscosity, or phase separation.

- **Microbial Growth Study:** No microbial colonies were observed on nutrient agar plates after incubation, indicating good microbiological stability.

- **Washability:** The serum was easily washable with plain water and did not leave any greasy or sticky residue on the skin.

Table 05: Results of Face Serum.

Evaluation Parameters	Face Serum
pH Value Range (4.5-6.5)	4.73
Surface tension (dynes/cm) Range (35-55dynes/cm)	45.85826
Stickiness test	Non- sticky
Viscosity (cp) Range(1.0-3.0 cp)	1.3713
Spreadability Test	Good
Skin irritation	Nill
Light exposure test	Stable

Homogeneity	Clear and uniform
Washability	Washable with plain water.
Temperature variation	Stable(no change)
Microbial Growth	Nill
Washability	Washable with plain water.

CONCLUSION

The present investigation was carried out to develop and evaluate cosmetic face toner and face serum formulations using pineapple peel extract as a natural active ingredient. Pineapple peel, which is normally discarded as waste, was successfully utilized as a valuable source of bioactive constituents such as bromelain, phenolic compounds, and antioxidants that are beneficial for skin care. Ethanolic extracts of pineapple peel prepared using 30% and 70% ethanol were incorporated into toner and serum formulations. The prepared products showed satisfactory physicochemical properties, including suitable pH, acceptable viscosity, good surface tension, non-sticky nature, and uniform appearance. Stability studies confirmed that the formulations remained physically stable under different temperature conditions and light exposure. Skin irritation tests indicated that the formulations were safe and did not produce significant adverse effects. Microbial studies showed the absence of microbial growth, confirming good microbiological quality.

Overall, the results demonstrate that pineapple peel extract can be effectively used in cosmetic toner and serum formulations to produce safe, stable, and effective herbal cosmetic products. The study also highlights the importance of utilizing agro-waste materials for the development of value-added and environmentally friendly cosmetic formulations.

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