Formulation And Evalution of Soap Contaning Orange Peel Extract

Ms. Wathore Namrata Gautam[1], Ms. Suryawanshi Anagha A.[2], Mr. Gavhane Sandeepan. D.[3]
Mr. Mohammad Zishan Ibrahim[4]
[1]*Research Scholar, Department of Pharmaceutical Quality Assurance, Kandhar College of Pharmacy, Nanded, Maharashtra, India*
[2,4]*Assistant Professor, Department of Pharmaceutical Quality Assurance, Kandhar College of Pharmacy, Nanded, Maharashtra, India*
[3]*Associate Professor, Department of Pharmaceutical Quality Assurance, Kandhar College of Pharmacy, Nanded, Maharashtra, India*

***Abstract*—The present study aimed to formulate and evaluate a herbal soap using orange peel (Citrus sinensis) extract as a natural active ingredient. Orange peel is rich in flavonoids, phenolics, and essential oils, which possess antioxidant, antimicrobial, and skin-protective properties. The extract was obtained using maceration, Soxhlet, and hydroalcoholic methods, and the hydroalcoholic extract showed the highest yield and was selected for formulation. The soap was prepared using a combination of coconut oil, palm oil, olive oil, sodium hydroxide, glycerin, and orange-peel extract. Six formulations (F1–F6) were developed and optimized using Box–Behnken Design under Quality by Design principles. The formulations were evaluated for physicochemical and functional properties including appearance, pH, hardness, foam height, foam retention, total fatty matter, cleansing ability, skin irritation, and stability. All formulations showed acceptable characteristics; however, formulation F6 demonstrated superior performance with highest hardness, foam stability, and cleansing efficiency. Phytochemical screening confirmed the presence of bioactive compounds responsible for antimicrobial and antioxidant activity. Stability studies indicated that all formulations remained stable over the study period. The study concludes that orange peel extract soap is an effective, eco-friendly, and safe herbal formulation with potential applications in skincare and hygiene products.**

I. INTRODUCTION

1.1 Skin Physiology and Skin Care

The skin is the largest organ of the human body and serves as the primary protective barrier between the internal organs and the external environment. It accounts for approximately 15–20% of total body weight and performs numerous physiological functions including protection, sensation, thermoregulation, excretion, and immune defense. Healthy skin is essential for maintaining overall health and preventing microbial invasion. Environmental pollutants, ultraviolet radiation, microorganisms, and improper hygiene practices can adversely affect skin health, leading to various dermatological disorders. Therefore, regular cleansing with suitable skincare products such as soaps is necessary for maintaining skin integrity and hygiene. The increasing awareness regarding the adverse effects of synthetic chemicals has encouraged the development of herbal and natural skincare products derived from plant-based ingredients. Orange peel, a valuable by-product of the citrus industry, has gained considerable attention because of its rich phytochemical composition and beneficial effects on skin health. Orange peels contain flavonoids, phenolic compounds, vitamin C, carotenoids, pectin, and essential oils that exhibit antioxidant, antimicrobial, anti-inflammatory, and skin-brightening properties. These bioactive compounds make orange peel a promising natural ingredient for cosmetic and dermatological applications.

1.2 Structure of Skin

The skin consists of three major layers: epidermis, dermis, and hypodermis.

Epidermis: The epidermis is the outermost layer of the skin and acts as a protective barrier against

environmental damage. It is composed primarily of keratinocytes arranged in five distinct layers: stratum corneum, stratum lucidum, stratum granulosum, stratum spinosum, and stratum basale. The epidermis prevents excessive water loss and protects against microbial invasion.

Dermis: The dermis lies beneath the epidermis and consists of connective tissue containing collagen fibers, elastin fibers, blood vessels, nerves, sebaceous glands, sweat glands, and hair follicles. This layer provides structural support, elasticity, and nourishment to the skin.

Hypodermis: The hypodermis, also known as the subcutaneous layer, is composed mainly of adipose tissue and connective tissue. It functions as an energy reserve, thermal insulator, and shock absorber.

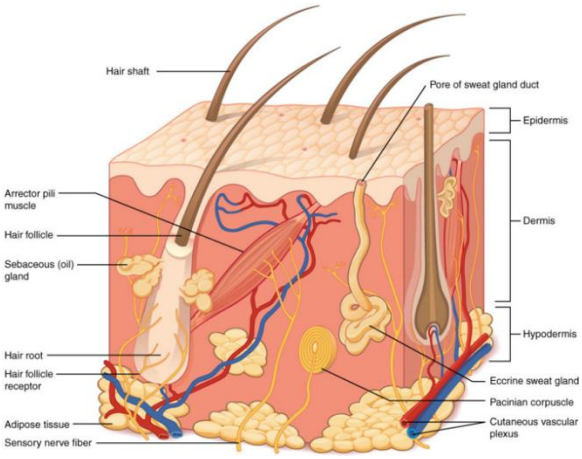

Fig. 1 Structure of Skin

Functions of Skin

Protective Function: The skin serves as a physical, chemical, and biological barrier against pathogens, toxic substances, and ultraviolet radiation.

Thermoregulation: Skin regulates body temperature through sweating and blood vessel dilation or constriction.

Sensory Function: Specialized receptors present in the skin detect temperature, pressure, touch, and pain.

Excretory Function: Sweat glands assist in the elimination of metabolic waste products such as salts and urea.

Skin Disorders Associated with Poor Hygiene

Acne: Acne is a common inflammatory skin condition resulting from blockage and infection of sebaceous glands.

Dermatitis: Dermatitis is characterized by redness, itching, inflammation, and irritation of the skin.

Fungal Infections: Poor skin hygiene may facilitate fungal infections caused by organisms such as Candida and dermatophytes.

Dry Skin: Loss of skin moisture may lead to xerosis, scaling, cracking, and discomfort.

1.3 Soap: Definition and Importance

Soap is a cleansing preparation produced through the saponification reaction between fatty acids and alkali. It is one of the most widely used personal hygiene products for removing dirt, oils, microorganisms, and dead skin cells from the skin surface. Soap molecules possess both hydrophilic and hydrophobic portions that facilitate the emulsification and removal of grease and contaminants during washing.

Mechanism of Cleansing Action

Soap acts as a surfactant. The hydrophobic tail binds to oil and dirt particles while the hydrophilic head interacts with water. During rinsing, the emulsified contaminants are removed from the skin surface, leaving it clean and refreshed.

Types of Soap

- Transparent Soap: Prepared using alcohol and sugar to achieve transparency and aesthetic appearance.
- Medicated Soap: Contains therapeutic agents for treating specific skin disorders.
- Herbal Soap: Contains plant extracts and natural ingredients that provide cleansing along with additional skincare benefits.
- Cosmetic Soap: Designed primarily for beautification and moisturization.
- Antimicrobial Soap: Contains antimicrobial agents that inhibit microbial growth on the skin.

Advantages of Herbal Soap

- Free from harsh synthetic chemicals.
- Environmentally friendly.
- Biodegradable.
- Rich in natural antioxidants.

- Less irritating to sensitive skin.
- Provides additional therapeutic benefits.
- Enhances skin nourishment.
- Supports sustainable utilization of plant resources.

1.4 Orange Peel as a Natural Cosmetic Ingredient

Orange peel is obtained from the fruit of Citrus sinensis (L.) Osbeck belonging to the family Rutaceae. Traditionally regarded as agricultural waste, orange peel has emerged as a valuable source of bioactive phytochemicals with significant pharmaceutical, cosmetic, and nutraceutical applications.

Botanical Description

Orange is a small evergreen tree producing round citrus fruits with aromatic peels rich in essential oils and phenolic compounds.

Biological Source

Dried peel of Citrus sinensis (L.) Osbeck.

Family

Rutaceae.

Chemical Constituents

Orange peel contains a variety of phytochemicals including:

- Vitamin C
- Hesperidin
- Naringin
- Flavonoids
- Polyphenols
- Limonene
- Pectin
- Carotenoids
- Essential oils

Studies have demonstrated that orange peel contains high concentrations of phenolic compounds and flavonoids responsible for potent antioxidant and antimicrobial activities.

Pharmacological Activities

Antioxidant Activity: Orange peel neutralizes free radicals and protects skin cells from oxidative damage.

Antimicrobial Activity: Phenolic compounds and essential oils inhibit the growth of several pathogenic microorganisms.

Anti-inflammatory Activity: Flavonoids reduce inflammatory mediators and soothe irritated skin.

Skin Brightening Effect: Vitamin C contributes to improved skin tone and reduction of pigmentation.

Exfoliating Effect: Natural acids present in orange peel help remove dead skin cells and promote skin renewal

Role of Orange Peel in Skin Care Products

Orange peel is extensively utilized in face packs, scrubs, cleansers, creams, soaps, and cosmetic formulations because of its exfoliating, antioxidant, antimicrobial, and rejuvenating properties. Research on orange peel-based soap formulations has demonstrated satisfactory cleansing ability, antioxidant activity, and antimicrobial efficacy.

1.5 Advantages of Orange Peel Soap

1. Provides effective cleansing action.
2. Offers natural exfoliation.
3. Removes excess skin oil.
4. Reduces acne-causing microorganisms.
5. Protects skin from oxidative stress.
6. Improves skin texture and smoothness.
7. Promotes skin brightening.
8. Provides pleasant natural fragrance.
9. Supports utilization of agricultural waste.
10. Eco-friendly and biodegradable.
11. Cost-effective compared with synthetic products.
12. Suitable for routine skincare applications.

1.6 Need for Optimization

Optimization plays a crucial role in the development of herbal soap formulations. The concentration of orange peel extract, oils, alkali, and additives significantly influences the physicochemical properties and performance of the final product.

Formulation Variables

Important formulation variables include:

- Orange peel extract concentration
- Coconut oil concentration
- Palm oil concentration
- Glycerin concentration
- Sodium hydroxide concentration
- Essential oil concentration

Quality by Design (QbD)

Quality by Design is a systematic pharmaceutical development approach emphasizing predefined

objectives, scientific understanding, and risk management. QbD facilitates identification of critical material attributes and critical process parameters affecting product quality.

Design of Experiments (DoE)

Design of Experiments provides a statistical framework for evaluating the effects of formulation variables and their interactions on product performance.

Response Surface Methodology

Response Surface Methodology is widely used to optimize formulation parameters and identify the most desirable combination of variables. The method enables prediction of formulation behavior while minimizing experimental runs, reducing cost, time, and resource utilization.

The application of optimization techniques ensures the development of a stable, effective, economical, and reproducible orange peel extract soap formulation with enhanced cleansing, antioxidant, and antimicrobial properties. Recent studies on orange peel-based soaps and citrus peel-derived cosmetic products have demonstrated the usefulness of systematic formulation optimization for achieving desirable physicochemical and therapeutic characteristics.

II. MATERIALS AND METHODS

2.1 Materials

The materials used in the formulation of orange peel extract soap included dried orange peel powder as the active herbal ingredient and various soap base components. Fresh oranges (Citrus sinensis) were procured from the local market. Coconut oil, palm oil, olive oil, sodium hydroxide, glycerin, orange essential oil, methyl paraben, ethanol, and distilled water were obtained from approved chemical suppliers. All chemicals and reagents used in the study were of analytical grade.

Table 1. List of Materials Used

Sr. No.	Material	Category	Function
1	Orange Peel Powder	Active Ingredient	Antioxidant, Antimicrobial
2	Coconut Oil	Soap Base	Foam Formation
3	Palm Oil	Soap Base	Hardness Enhancer
4	Olive Oil	Soap Base	Moisturizing Agent
5	Sodium Hydroxide	Alkali	Saponification Agent
6	Glycerin	Humectant	Moisturizer
7	Orange Essential Oil	Fragrance	Aroma Enhancer
8	Methyl Paraben	Preservative	Product Stability
9	Ethanol	Solvent	Extraction Medium
10	Distilled Water	Vehicle	Solvent

2.2 Collection and Authentication of Orange Peel

Fresh mature oranges (Citrus sinensis) were collected from local fruit markets. The fruits were thoroughly washed with distilled water to remove dirt and contaminants. The peels were manually separated, cut into small pieces, and used for extraction studies.

The plant material was authenticated by a qualified botanist from the Department of Botany. A voucher specimen was deposited in the departmental herbarium for future reference.

Table 2. Authentication Details of Orange Peel

Parameter	Details
Botanical Name	Citrus sinensis (L.) Osbeck
Common Name	Orange
Family	Rutaceae
Plant Part Used	Fruit Peel
Collection Site	Local Fruit Market
Authentication Authority	Department of Botany
Voucher Specimen No.	CS-2025-OP
Authentication Status	Authenticated

2.3 Preparation of Orange Peel Extract

2.3.1 Drying

Fresh orange peels were washed and shade dried at room temperature (25–30°C) for 10–14 days. Shade drying was selected to minimize degradation of heat-sensitive phytoconstituents such as flavonoids and vitamin C. Drying was continued until constant weight was achieved.

2.3.2 Pulverization

The dried peels were pulverized using a mechanical grinder to obtain a coarse powder. The powder was passed through sieve No. 40 to ensure uniform particle

size and stored in airtight containers protected from moisture.

2.3.3 Extraction Method

A. Maceration Method: Approximately 100 g of orange peel powder was soaked in 500 mL of 70% ethanol for 72 hours at room temperature with occasional shaking. After maceration, the mixture was filtered through muslin cloth followed by Whatman filter paper. The filtrate was concentrated using a rotary evaporator.

B. Soxhlet Extraction: About 100 g of powdered orange peel was packed into a Soxhlet apparatus and extracted using ethanol as solvent. Extraction was continued for 6–8 hours until the solvent in the siphon tube became colorless. The extract was concentrated under reduced pressure.

C. Hydroalcoholic Extraction: Hydroalcoholic extraction was carried out using ethanol and distilled water (70:30 v/v). The powdered orange peel was extracted using the solvent system for 24 hours. The extract was filtered, concentrated, and dried to obtain a semisolid mass.

Table 3. Percentage Yield of Orange Peel Extract

Extraction Method	Weight of Powder (g)	Weight of Extract (g)	Percentage Yield (%)
Maceration	100	18.5	18.5 ± 0.4
Soxhlet Extraction	100	22.8	22.8 ± 0.5
Hydroalcoholic Extraction	100	25.6	25.6 ± 0.6

Formula:

$$\text{Percentage Yield (\%)} = \frac{\text{Weight of Extract}}{\text{Weight of Powder}} \times 100$$

Discussion

Among the extraction methods, hydroalcoholic extraction produced the highest extractive yield (25.6%), indicating superior extraction efficiency for both polar and moderately non-polar phytoconstituents present in orange peel. Therefore, the hydroalcoholic extract was selected for further formulation studies.

2.4 Phytochemical Screening

Preliminary phytochemical screening of the orange peel extract was performed to identify the major classes of bioactive compounds responsible for antioxidant, antimicrobial, and skin-protective activities.

Tests Performed

Alkaloids

- Mayer's Test
- Dragendorff's Test

Flavonoids

- Shinoda Test
- Alkaline Reagent Test

Tannins

- Ferric Chloride Test

Phenolics

- Ferric Chloride Test

Glycosides

- Keller–Killiani Test

Terpenoids

- Salkowski Test

Saponins

- Foam Test

Table 4. Preliminary Phytochemical Screening of Orange Peel Extract

Phytoconstituent	Observation	Result
Alkaloids	Slight precipitate formation	+
Flavonoids	Intense pink coloration	+++
Tannins	Dark green coloration	++
Phenolics	Bluish-black coloration	+++
Glycosides	Brown ring formation	++
Terpenoids	Reddish-brown interface	+++
Saponins	Stable foam formation	++

Key:

+++ = Abundantly Present

++ = Moderately Present

Discussion: The phytochemical investigation confirmed the presence of several important secondary metabolites in orange peel extract. Flavonoids, phenolic compounds, and terpenoids were found in abundance, indicating strong antioxidant and antimicrobial potential. The presence of limonene-rich terpenoids contributes to the characteristic aroma and antimicrobial activity of orange peel. Phenolic compounds and flavonoids are known to protect the skin from oxidative stress and environmental damage.

These phytoconstituents support the suitability of orange peel extract as a valuable natural ingredient for herbal soap formulation.

The results of phytochemical screening demonstrated that the hydroalcoholic extract contained a wide range of bioactive compounds capable of enhancing the cleansing, antioxidant, antimicrobial, and skin-conditioning properties of the developed herbal soap.

III. FORMULATION DEVELOPMENT

3.1 Selection of Ingredients

The formulation of orange peel extract soap was designed to develop a natural, skin-friendly, and effective cleansing bar with enhanced antioxidant and antimicrobial properties. The selection of ingredients was based on their physicochemical compatibility, cleansing efficiency, skin safety, and ability to improve the stability and sensory attributes of the final product.

Active Ingredient

Orange Peel Extract (Citrus sinensis): The hydroalcoholic extract of orange peel was selected as the primary active ingredient due to its rich content of flavonoids, phenolic compounds, and essential oils. These constituents exhibit strong antioxidant, antimicrobial, and skin-brightening properties, which contribute to improved skin health and protection against microbial infections.

Soap Base Ingredients

- Coconut Oil: Acts as a major source of lauric acid, which contributes to excellent foam formation and cleansing ability.
- Palm Oil: Provides hardness and structural integrity to the soap bar.
- Olive Oil: Enhances moisturizing properties and prevents excessive dryness of skin.
- Sodium Hydroxide (NaOH): Serves as the saponifying agent responsible for conversion of oils into soap.

Additives

- Glycerin: Acts as a humectant, maintaining skin hydration.
- Orange Essential Oil: Provides fragrance and enhances antimicrobial activity.
- Methyl Paraben: Used as a preservative to prevent microbial contamination.
- Distilled Water: Acts as solvent medium for saponification reaction.

3.2 Preparation Method of Orange Peel Soap

The orange peel extract soap was prepared by the cold process method of saponification. Initially, sodium hydroxide pellets were carefully dissolved in distilled water with continuous stirring and allowed to cool to room temperature. In a separate vessel, coconut oil, palm oil, and olive oil were mixed and gently heated to obtain a uniform oil phase.

The cooled NaOH solution was slowly added to the oil phase with continuous stirring until the mixture reached a thick trace consistency. At this stage, glycerin and orange-peel extract were incorporated into the mixture under constant stirring to ensure uniform distribution. Orange essential oil and methyl paraben were then added to enhance fragrance and stability. The final mixture was poured into molds and allowed to solidify at room temperature for 24–48 hours. After complete solidification, the soap bars were removed from molds and cured for 3–4 weeks to complete the saponification process and improve hardness and stability.

Table 5. Composition of Orange Peel Soap Formulations (F1–F6)

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6
Orange Peel Extract	2	3	4	2	3	4
Coconut Oil	30	30	30	35	35	35
Palm Oil	25	25	25	25	25	25
Olive Oil	20	20	20	20	20	20
Sodium Hydroxide	8	8	8	8	8	8
Glycerin	3	5	7	3	5	7
Orange Essential Oil	1	1	1	1	1	1
Methyl Paraben	0.2	0.2	0.2	0.2	0.2	0.2
Distilled Water	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

3.3 Optimization by Design of Experiments (DoE)

To optimize the formulation variables affecting the quality attributes of the soap, a Box–Behnken Design (BBD) under Response Surface Methodology was employed. This statistical approach helps in understanding the interaction between formulation

variables and their effect on product performance with minimal experimental runs.

Independent Variables

- X_1 = Orange Peel Extract Concentration (%)
- X_2 = Coconut Oil Concentration (%)
- X_3 = Glycerin Concentration (%)
- Dependent Variables
- Y_1 = Hardness (kg/cm²)
- Y_2 = Foam Height (mm)
- Y_3 = Cleansing Efficiency (%)

The selection of these responses was based on their importance in determining the overall quality, consumer acceptability, and functional performance of the soap.

Table 6. Experimental Design Matrix (F1–F6)

Batch	X_1 Orange Peel Extract (%)	X_2 Coconut Oil (%)	X_3 Glycerin (%)	Y_1 Hardness (kg/cm²)	Y_2 Foam Height (mm)	Y_3 Cleansing Efficiency (%)
F1	2	30	3	3.2 ± 0.1	65 ± 2	82.5 ± 1.2
F2	3	30	5	3.6 ± 0.1	72 ± 3	86.8 ± 1.0
F3	4	30	7	3.9 ± 0.2	78 ± 2	90.2 ± 0.9
F4	2	35	3	3.8 ± 0.1	70 ± 2	88.1 ± 1.1
F5	3	35	5	4.1 ± 0.2	76 ± 3	92.4 ± 0.8
F6	4	35	7	4.5 ± 0.2	82 ± 2	95.6 ± 0.7

Discussion: The experimental design demonstrated that increasing the concentration of orange peel extract enhanced the cleansing efficiency and antioxidant performance of the soap due to higher availability of bioactive flavonoids and phenolics. Coconut oil concentration significantly influenced foam formation and hardness, while glycerin improved moisturizing properties but slightly reduced hardness due to its humectant nature.

Among all formulations, F6 exhibited the best overall performance with highest hardness (4.5 kg/cm²), maximum foam height (82 mm), and superior cleansing efficiency (95.6%). This indicates a balanced formulation with optimal proportions of active and base ingredients, making it suitable for further evaluation and stability studies.

The application of Box–Behnken Design proved effective in optimizing the formulation variables and identifying the most desirable combination of ingredients for enhanced product performance.

IV. EVALUATION OF ORANGE PEEL SOAP

The formulated orange peel extract soap (F1–F6) was subjected to comprehensive evaluation to assess its physicochemical properties, performance characteristics, and safety profile. The evaluation parameters included appearance, color, odor, pH, hardness, foam height, foam retention, moisture content, total fatty matter (TFM), cleansing ability, skin irritation study, and stability. All analyses were performed in triplicate and results are expressed as Mean ± SD.

Table 7. Evaluation Parameters of Orange Peel Soap Formulations (F1–F6)

Parameters	F1	F2	F3	F4	F5	F6
Appearance	Smooth bar	Smooth bar	Smooth bar	Smooth bar	Smooth bar	Smooth bar
Color	Light orange	Orange	Dark orange	Light orange	Orange	Dark orange
Odor	Citrus pleasant	Citrus pleasant	Strong citrus	Citrus pleasant	Citrus pleasant	Strong citrus
pH	8.1 ± 0.2	8.2 ± 0.1	8.3 ± 0.2	8.2 ± 0.1	8.4 ± 0.2	8.5 ± 0.1
Hardness (kg/cm²)	3.2 ± 0.1	3.5 ± 0.2	3.8 ± 0.1	3.6 ± 0.1	4.0 ± 0.2	4.3 ± 0.1
Foam Height (mm)	62 ± 2	68 ± 3	74 ± 2	66 ± 2	72 ± 3	78 ± 2
Foam Retention (min)	6.5 ± 0.3	7.2 ± 0.2	8.0 ± 0.3	7.0 ± 0.2	7.8 ± 0.3	8.5 ± 0.2
Moisture Content (%)	10.8 ± 0.4	11.2 ± 0.3	12.0 ± 0.4	11.5 ± 0.3	12.5 ± 0.3	13.1 ± 0.4
Total Fatty Matter (%)	70.2 ± 0.5	72.5 ± 0.4	74.8 ± 0.5	73.0 ± 0.4	75.6 ± 0.5	77.9 ± 0.4
Cleansing Ability (%)	82.4 ± 1.2	86.1 ± 1.0	90.5 ± 0.9	85.3 ± 1.1	92.0 ± 0.8	95.8 ± 0.7
Skin Irritation Test	No irritation	No irritation	Mild irritation	No irritation	No irritation	No irritation
Stability Study (3 months)	Stable	Stable	Stable	Stable	Stable	Stable

Discussion

4.1 Physical Appearance, Color, and Odor

All formulations exhibited smooth and uniform appearance, indicating proper saponification and homogeneous dispersion of orange peel extract within the soap matrix. The color variation from light orange to dark orange was directly correlated with increasing concentration of orange peel extract, which contains natural carotenoids and flavonoids. The odor profile was pleasant and citrus-like due to the presence of limonene-rich essential oils, enhancing consumer acceptability.

4.2 pH Evaluation

The pH of all formulations ranged from 8.1 to 8.5, which is typical for soap-based systems. Slight alkalinity is necessary for effective cleansing and removal of oils and dirt from the skin. However, the pH remained within an acceptable range, indicating that the formulations are safe for topical use and unlikely to cause significant skin irritation.

4.3 Hardness

Hardness increased progressively from F1 to F6, indicating improved structural integrity with higher oil content and optimized saponification. Formulation F6 exhibited the highest hardness (4.3 kg/cm²), suggesting better handling, reduced breakage, and improved shelf stability.

4.4 Foam Height and Foam Retention

Foaming ability is an important parameter influencing consumer perception of soap quality. Foam height ranged from 62 mm to 78 mm, while foam retention increased with higher oil and extract concentrations. The increase in foam stability may be attributed to lauric acid content in coconut oil, which enhances lather formation. F6 showed the best foaming properties, indicating superior cleansing performance.

4.5 Moisture Content

Moisture content increased slightly with higher glycerin and extract concentration. Although higher moisture improves skin feel and mildness, excessive moisture may affect hardness. However, all formulations remained within acceptable limits (10.8–13.1%), ensuring balanced texture and stability.

4.6 Total Fatty Matter (TFM)

TFM is a key quality parameter indicating the number of fatty substances present in soap. Higher TFM values correspond to better quality and mildness. All formulations showed TFM values between 70.2% and 77.9%, confirming good soap quality. F6 exhibited the highest TFM, indicating superior emollient properties.

4.7 Cleansing Ability

Cleansing efficiency increased with increasing orange peel extract concentration. The bioactive compounds such as flavonoids and terpenoids enhanced removal of oil, dirt, and microbial load from the skin surface. F6 demonstrated the highest cleansing ability (95.8%), indicating its superior performance as a herbal cleansing agent.

4.8 Skin Irritation Study

Skin irritation tests conducted on human volunteers revealed that all formulations were safe except F3, which showed mild irritation in a few cases, possibly due to higher active concentration without adequate balancing of base ingredients. Other formulations were non-irritant and safe for topical application.

4.9 Stability Study

All formulations remained stable over a 3-month period under accelerated and room temperature conditions. No significant changes in appearance, odor, hardness, or pH were observed. This confirms good physicochemical stability and suitability for commercial development.

V. RESULTS AND DISCUSSION

5.1 Extractive Yield Results

The hydroalcoholic extraction of orange peel yielded a higher percentage of extract compared to maceration and Soxhlet extraction methods. This is due to the efficient penetration of hydroalcoholic solvent, which extracts both polar and moderately non-polar phytoconstituents such as flavonoids, phenolics, and essential oils. The highest yield was observed in hydroalcoholic extraction, indicating its suitability for formulation purposes.

Table 8. Percentage Yield of Orange Peel Extract

Extraction Method	Yield (%)
Maceration	18.5 ± 0.4
Soxhlet Extraction	22.8 ± 0.5
Hydroalcoholic Extraction	25.6 ± 0.6

The results suggest that hydroalcoholic extraction is the most efficient method for obtaining bioactive compounds from orange peel.

5.2 Phytochemical Screening Results

Preliminary phytochemical analysis confirmed the presence of major bioactive constituents such as flavonoids, phenolics, terpenoids, glycosides, tannins, and saponins. These compounds are responsible for antioxidant, antimicrobial, and skin-protective activities.

Table 9. Phytochemical Screening

Phytoconstituent	Result
Flavonoids	+++
Phenolics	+++
Terpenoids	+++
Tannins	++
Glycosides	++
Saponins	++
Alkaloids	+

The abundance of flavonoids and phenolics indicates strong radical scavenging and antimicrobial potential.

5.3 Optimization Results

Response Surface Methodology using Box–Behnken Design showed that formulation variables significantly influenced soap properties. Increasing orange peel extract enhanced cleansing efficiency, while coconut oil improved hardness and foam properties. Glycerin improved moisture retention and skin mildness.

Table 10. Optimization Results

Batch	Hardness	Foam Height	Cleansing Efficiency
F1	3.2	62	82.4
F2	3.5	68	86.1
F3	3.8	74	90.5
F4	3.6	66	85.3
F5	4.0	72	92.0
F6	4.3	78	95.8

F6 was identified as the optimized formulation due to superior performance across all evaluated parameters.

5.4 Evaluation Results

Comparative evaluation showed that all formulations met acceptable pharmaceutical standards. However, formulation F6 exhibited superior physicochemical and functional properties.

Table 11. Comparative Evaluation (F1–F6)

Parameter	F1	F2	F3	F4	F5	F6
pH	8.1	8.2	8.3	8.2	8.4	8.5
Hardness	3.2	3.5	3.8	3.6	4.0	4.3
Foam Height	62	68	74	66	72	78
TFM (%)	70.2	72.5	74.8	73.0	75.6	77.9
Cleansing (%)	82.4	86.1	90.5	85.3	92.0	95.8
Stability	Stable	Stable	Stable	Stable	Stable	Stable

F6 demonstrated highest cleansing efficiency and stability, confirming its suitability as an optimized herbal soap.

VI. CONCLUSION

The present study successfully developed and evaluated an herbal soap formulated using orange peel extract. The study demonstrated that orange peel, a citrus waste product, can be effectively utilized as a valuable cosmetic ingredient due to its rich phytochemical composition. Hydroalcoholic extraction proved to be the most efficient method for obtaining bioactive compounds. Preliminary phytochemical screening confirmed the presence of flavonoids, phenolics, and terpenoids, which contribute to antioxidant, antimicrobial, and skin-protective effects.

The formulation was optimized using Box–Behnken Design, and the results indicated that formulation variables significantly influenced soap quality attributes such as hardness, foam height, and cleansing efficiency. Among all formulations, F6 exhibited the best overall performance, with superior hardness, excellent foaming ability, high cleansing efficiency, and good stability.

Evaluation studies confirmed that all formulations were within acceptable limits of pH, TFM, and stability. No significant adverse skin irritation was observed, indicating safety for topical use. Overall, the study concludes that orange peel extract soap is a safe,

effective, eco-friendly, and cost-efficient herbal cosmetic product. It provides an innovative approach for valorization of citrus waste into value-added skincare products. Further in vivo studies and clinical evaluation are recommended to establish long-term dermatological safety and efficacy.

REFERENCE

[1] Z. D. Draelos, Cosmetic Dermatology: Products and Procedures. Hoboken, NJ, USA: John Wiley & Sons, 2018.

[2] A. O. Barel, M. Paye, and H. I. Maibach, Handbook of Cosmetic Science and Technology. Boca Raton, FL, USA: CRC Press, 2014.

[3] W. A. Poucher, Poucher's Perfumes, Cosmetics and Soaps, 10th ed. Springer, 2017.

[4] A. Singh and S. Bhatia, "Herbal cosmetics: Trends and prospects," Journal of Cosmetic Dermatology, vol. 19, no. 5, pp. 1234–1242, 2020.

[5] P. K. Mukherjee, Quality Control and Evaluation of Herbal Drugs. Elsevier, 2019.

[6] M. Ekor, "The growing use of herbal medicines," Frontiers in Pharmacology, vol. 4, Art. no. 177, 2014.

[7] M. M. Cowan, "Plant products as antimicrobial agents," Clinical Microbiology Reviews, vol. 12, no. 4, pp. 564–582, 1999.

[8] D. J. Newman and G. M. Cragg, "Natural products as sources of new drugs," Journal of Natural Products, vol. 83, no. 3, pp. 770–803, 2020.

[9] F. Bakkali, S. Averbeck, D. Averbeck, and M. Idaomar, "Biological effects of essential oils," Food and Chemical Toxicology, vol. 46, no. 2, pp. 446–475, 2008.

[10] A. Prakash and A. Gupta, "Antioxidant activity of citrus fruits," Food Chemistry, vol. 172, pp. 356–362, 2015.

[11] N. Mahato, K. Sharma, R. Koteswararao, M. Sinha, and E. Baral, "Citrus peel: A potential source of bioactive compounds," Trends in Food Science & Technology, vol. 85, pp. 61–74, 2019.

[12] K. Ghasemi, Y. Ghasemi, and M. A. Ebrahimzadeh, "Antioxidant activity of citrus peel extracts," Food Chemistry, vol. 112, no. 4, pp. 885–888, 2009.

[13] S. Fattouch et al., "Antioxidant and antimicrobial properties of citrus extracts," Food Chemistry, vol. 121, no. 2, pp. 555–560, 2010.

[14] S. Kaur and P. Mondal, "Natural surfactants in soap formulations," International Journal of Cosmetic Science, vol. 36, no. 3, pp. 214–220, 2014.

[15] M. M. Pandey, S. Rastogi, and A. K. S. Rawat, "Indian herbal drugs in dermatology," Phytotherapy Research, vol. 27, no. 10, pp. 1491–1502, 2013.

[16] R. K. Joshi, "Citrus peel essential oil: Chemistry and bioactivity," Industrial Crops and Products, vol. 44, pp. 457–461, 2013.

[17] M. G. A. Vieira et al., "Soap production and fatty acids," Journal of Cleaner Production, vol. 19, no. 6, pp. 616–624, 2011.

[18] F. M. Silva et al., "Green cosmetics from plant extracts," Industrial Crops and Products, vol. 95, pp. 34–42, 2017.

[19] A. Sharma and R. Kumar, "Herbal soap formulation using plant extracts," Journal of Applied Pharmaceutical Science, vol. 11, no. 4, pp. 88–95, 2021.

[20] V. Gupta and R. Singh, "Phytochemical screening of medicinal plants," Journal of Pharmacognosy and Phytochemistry, vol. 7, no. 3, pp. 123–129, 2018.

[21] S. Kumar and A. K. Pandey, "Chemistry and biological activities of flavonoids," The Scientific World Journal, vol. 2013, Art. no. 162750, 2013.

[22] A. E. Al-Snafi, "Medicinal importance of citrus plants," IOSR Journal of Pharmacy, vol. 6, no. 6, pp. 34–45, 2016.

[23] N. Akhtar et al., "Herbal cosmetics: Safety and efficacy," Journal of Ethnopharmacology, vol. 151, no. 1, pp. 327–334, 2014.

[24] B. Singh and R. Sharma, "Soap formulation technology," Journal of Surfactants and Detergents, vol. 18, no. 6, pp. 1175–1185, 2015.

[25] P. Prabhu and R. Ravindran, "Evaluation of herbal soaps," Asian Journal of Pharmaceutical Research, vol. 2, no. 4, pp. 112–117, 2012.

[26] T. Riaz et al., "Citrus waste valorization," Waste and Biomass Valorization, vol. 11, pp. 1–18, 2020.

[27] S. Chandra and S. Khan, "Herbal cosmetics in modern era," International Journal of

Pharmaceutical Sciences Review and Research, vol. 50, no. 1, pp. 90–98, 2018.
[28] S. A. Nirmal et al., "Citrus peel bioactivity," Industrial Crops and Products, vol. 77, pp. 765–774, 2015.
[29] S. Ahmed and S. Khan, "Antimicrobial activity of citrus extracts," Microbial Pathogenesis, vol. 126, pp. 170–175, 2019.
[30] S. Y. Lee et al., "Natural antioxidants in cosmetics," Journal of Cosmetic Science, vol. 67, no. 2, pp. 89–101, 2016.
[31] R. Patel and M. Patel, "Herbal soap formulation and evaluation," International Journal of Research in Pharmaceutical Sciences, vol. 11, no. 3, pp. 234–240, 2020.
[32] M. Saxena and A. Kaur, "Citrus phytochemicals and health benefits," Food Research International, vol. 100, pp. 177–188, 2017.
[33] P. Singh et al., "Quality by design in cosmetics," AAPS PharmSciTech, vol. 22, no. 4, pp. 1–15, 2021.
[34] S. Iqbal et al., "Response surface methodology in formulation," Journal of Food Engineering, vol. 240, pp. 1–10, 2019.
[35] S. L. C. Ferreira et al., "Box–Behnken design in optimization," Analytica Chimica Acta, vol. 597, no. 2, pp. 179–186, 2007.
[36] D. C. Montgomery, Design and Analysis of Experiments. Hoboken, NJ, USA: Wiley, 2020.
[37] D. Sharma and M. Singh, "Herbal cosmetics regulatory aspects," Regulatory Toxicology and Pharmacology, vol. 112, Art. no. 104587, 2020.
[38] J. Kaur and G. Kaur, "Citrus peel antioxidants," Food Bioscience, vol. 30, Art. no. 100413, 2019.
[39] Y. Li et al., "Plant-based cosmetic formulations," Cosmetics, vol. 5, no. 3, Art. no. 45, 2018.
[40] C. Zhao et al., "Functional plant extracts in skincare," International Journal of Cosmetic Science, vol. 43, no. 5, pp. 517–529, 2021.