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Dedication

With profound gratitude and heartfelt respect, I dedicate this work to the memory of my beloved father, whose love, values, sacrifices, and guidance continue to inspire me every day. Although he is no longer by my side, his presence remains in my heart, and this achievement is a tribute to his enduring legacy. May he rest in peace.

To my dear mother, whose endless love, patience, support, and prayers have been my source of strength throughout every challenge and every success. Words cannot fully express my gratitude for all that she has done for me.

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Abstract:

Herbal cosmeceuticals have attracted increasing scientific and industrial interest because they combine the aesthetic role of cosmetics with the biological activity of plant-derived compounds. The present study aimed to prepare and evaluate a series of plant-based cosmetic formulations using medicinal plant extracts, vegetable oils, natural powders, and chlorophyll derivatives obtained from *Spinacia oleracea* L. (spinach). Several topical products were formulated, including a chemical antiperspirant cream, an antiperspirant foot cream, a pre-depilatory exfoliating cream, a post-depilatory soothing cream, a keratolytic wart-care cream, an antiperspirant foot gel, and two herbal charcoal soaps. In parallel, chlorophyll was extracted from spinach leaves by ethanolic extraction and converted into copper and sodium copper chlorophyllin complexes for potential cosmetic application. The prepared formulations were characterized through oil/aqueous phase balance, organoleptic observation, solubility and dispersion behavior, miscibility and centrifugation stability, pH and bromothymol blue indicator tests, long-term visual stability, preliminary skin tolerance, soap pH, free alkali content, foaming power, and DPPH antioxidant activity. The results showed that formulation behavior was strongly influenced by the ratio between hydrophilic, lipophilic, mineral, and powdered ingredients. The antiperspirant creams and hydroalcoholic foot gel showed pH values close to the skin-compatible range, whereas the exfoliating and post-depilatory creams were more alkaline due to their mineral-rich composition. The foot gel showed the best homogeneity after miscibility testing, while lipid- and powder-rich creams displayed phase separation under centrifugation stress. No visible irritation was observed during the preliminary skin tolerance test. The DPPH assay indicated antioxidant potential, particularly for spinach chlorophyll/chlorophyllin and selected botanical formulations. The herbal soaps showed acceptable pH, free alkali, and foaming behavior. Overall, the results suggest that plant-derived ingredients and spinach chlorophyll derivatives can be incorporated into functional cosmetic formulations. However, additional standardized microbiological, dermatological, and instrumental analyses are recommended to confirm their safety, stability, and cosmetic efficacy.

Keywords: Herbal cosmetics; cosmeceuticals; medicinal plants; *Spinacia oleracea*; chlorophyllin; herbal soap; antioxidant activity; formulation stability.

Résumé :

Les cosméceutiques à base de plantes ont suscité un intérêt scientifique et industriel croissant car ils combinent le rôle esthétique des cosmétiques avec l'activité biologique des composés d'origine végétale. La présente étude visait à préparer et évaluer une série de formulations cosmétiques à base de plantes en utilisant des extraits de plantes médicinales, des huiles végétales, des poudres naturelles et des dérivés de chlorophylle obtenus à partir de *Spinacia oleracea* L. (épinard). Plusieurs produits topiques ont été formulés, y compris une crème antitranspirante chimique, une crème antitranspirante pour les pieds, une crème exfoliante pré-dépilatoire, une crème apaisante post-dépilatoire, une crème kératolytique pour les verrues, un gel antitranspirant pour les pieds et deux savons au charbon végétal. Parallèlement, la chlorophylle a été extraite des feuilles d'épinard par extraction éthanolique et convertie en complexes de chlorophylline de cuivre et de chlorophylline de cuivre sodique pour une application cosmétique potentielle. Les formulations préparées ont été caractérisées par l'équilibre entre les phases huileuse et aqueuse, l'observation organoleptique, le comportement de solubilité et de dispersion, la miscibilité et la stabilité à la centrifugation, les tests de pH et de l'indicateur bleu de bromothymol, la stabilité visuelle à long terme, la tolérance cutanée préliminaire, le pH du savon, la teneur en alcalis libres, le pouvoir moussant et l'activité antioxydante DPPH. Les résultats ont montré que le comportement des formulations était fortement influencé par le rapport entre les ingrédients hydrophiles, lipophiles, minéraux et en poudre. Les crèmes antitranspirantes et le gel hydroalcoolique pour les pieds ont montré des valeurs de pH proches de la plage compatible avec la peau, tandis que les crèmes exfoliantes et post-épilatoires étaient plus alcalines en raison de leur composition riche en minéraux. Le gel pour les pieds a montré la meilleure homogénéité après les tests de miscibilité, tandis que les crèmes riches en lipides et en poudre ont affiché une séparation de phase sous stress de centrifugation. Aucune irritation visible n'a été observée lors du test préliminaire de tolérance cutanée. Le test DPPH a indiqué un potentiel antioxydant, en particulier pour la chlorophylle/chlorophylline d'épinard et certaines formulations botaniques sélectionnées. Les savons à base de plantes ont montré un pH acceptable, une absence de soude libre et un comportement moussant. Dans l'ensemble, les résultats suggèrent que les ingrédients d'origine végétale et les dérivés de chlorophylle d'épinard peuvent être incorporés dans des formulations cosmétiques fonctionnelles. Cependant, des analyses microbiologiques, dermatologiques et instrumentales standardisées

supplémentaires sont recommandées pour confirmer leur sécurité, leur stabilité et leur efficacité cosmétique.

Mots-clés : Cosmétiques à base de plantes; cosméceutiques; plantes médicinales; *Spinacia oleracea*; chlorophylline; savon aux herbes; activité antioxydante; stabilité de la formulation

ملخص:

حظيت مستحضرات التجميل العشبية باهتمام علمي وصناعي متزايد لأنها تجمع بين الدور الجمالي لمستحضرات التجميل والنشاط البيولوجي للمركبات المشتقة من النباتات. هدفت هذه الدراسة إلى تحضير وتقييم سلسلة من تركيبات التجميل النباتية باستخدام مستخلصات النباتات الطبية، والزيوت النباتية، والمساحيق الطبيعية، ومشتقات الكلوروفيل المستخرجة من نبات السبانخ (*Spinacia oleracea* L.). تم تحضير عدة منتجات موضعية، شملت كريمًا كيميائيًا مضادًا للتعرق، وكريمًا مضادًا للتعرق للقدمين، وكريمًا مقشرًا قبل إزالة الشعر، وكريمًا مهدئًا بعد إزالة الشعر، وكريمًا لعلاج التآليل (مذيبيًا للقرنيات)، وجلاً مضادًا للتعرق للقدمين، وصابونين عشبين بالفحم. في الوقت نفسه، تم استخلاص الكلوروفيل من أوراق السبانخ باستخدام الاستخلاص الإيثانولي، وتحويله إلى معقدات نحاس الكلوروفيلين وصوديوم نحاس الكلوروفيلين لتطبيقات تجميلية محتملة. تم توصيف التركيبات المحضرة من خلال: توازن الطور الزيتي/المائي، والملاحظة الحسية (العضوية)، وسلوكية الذوبان والتشتت، والامتزاجية وثبات الطرد المركزي، واختبارات الأس الهيدروجيني وكاشف بروموثيمول الأزرق، والثبات البصري طويل المدى، والتحمل الجلدي الأولي، ودرجة حموضة الصابون، ومحتوى القلويات الحرة، وقوة الرغوة، والنشاط المضاد للأكسدة باستخدام اختبار DPPH. أظهرت النتائج أن سلوك التركيبات تأثر بشدة بنسبة المكونات المحبة للماء، والمحبة للدهون، والمعدنية، والمسحوقية. أظهرت كريمات مضادات التعرق والجل المائي الكحولي للقدمين قيم أس هيدروجيني قريبة من المدى المتوافق مع الجلد، بينما كانت كريمات التقشير وما بعد إزالة الشعر أكثر قلوية بسبب تركيبها الغني بالمواد المعدنية. أظهر جل القدمين أفضل تجانس بعد اختبار الامتزاجية، بينما أظهرت الكريمات الغنية بالدهون والمساحيق انفصالًا طوريًا تحت إجهاد الطرد المركزي. لم تلاحظ أي تهيجات مرئية أثناء اختبار التحمل الجلدي الأولي. أشار اختبار DPPH إلى إمكانية مضادات الأكسدة، خاصة لكلوروفيل/كلوروفيلين السبانخ وبعض التركيبات النباتية المختارة. أظهرت الصابونات العشبية قيم أس هيدروجيني مقبولة، ومحتوى قلوي حر، وسلوك رغوي مقبول. بشكل عام، تشير النتائج إلى إمكانية دمج المكونات النباتية ومشتقات كلوروفيل السبانخ في تركيبات تجميلية وظيفية. ومع ذلك، يُوصى بإجراء تحليلات ميكروبيولوجية وجلدية وأجهزة إضافية معيارية لتأكيد سلامتها وثباتها وفعاليتها التجميلية.

الكلمات المفتاحية: مستحضرات تجميل عشبية؛ مستحضرات تجميل دوائية؛ نباتات طبية؛ سبانخ؛ كلوروفيلين؛ صابون عشبي؛ نشاط مضاد للأكسدة؛ ثباتية التركيبية.

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General Introduction

Cosmeceuticals represent a hybrid category of products that bridge the gap between cosmetics and pharmaceuticals, containing biologically active ingredients that provide therapeutic benefits beyond traditional cosmetic applications [1]. Unlike conventional cosmetics that merely enhance appearance, cosmeceuticals penetrate the skin's deeper layers to deliver physiological benefits such as anti-aging, skin whitening, and photo protection [2]. The global cosmeceutical market has experienced exponential growth, driven by increasing consumer awareness about skin health and the demand for scientifically validated products with minimal side effects [3]. This growing preference for natural alternatives is largely explained by increasing awareness of the potential risks associated with synthetic substances, both for human health and the environment, prompting a clear shift toward plant-based products [4].

Medicinal plants have been used by humans for thousands of years as one of the earliest and most important sources of healing substances, forming the basis of traditional medical systems in many ancient civilizations, including Egyptian, Greek, and Chinese cultures, as well as in Indigenous practices across Africa, Asia, and the Americas [5,6]. Far from being only part of history, medicinal plants remain highly relevant today and continue to influence both traditional remedies and modern pharmaceutical research [7]. In the context of cosmeceuticals, herbal plants have emerged as invaluable resources due to their rich phytochemical profiles, safety profiles, and multifunctional properties [8]. These botanical ingredients contain bioactive compounds such as polyphenols, flavonoids, terpenoids, and alkaloids that exhibit antioxidant, anti-inflammatory, antimicrobial, and anti-aging activities [9]. Beyond therapeutic applications, their bioactive constituents are increasingly incorporated into cosmetic formulations to provide antioxidant, anti-inflammatory, and skin-protective benefits, thus representing a bridge between ancient wisdom and contemporary innovations in both healthcare and the cosmetic industry [10].

The shift toward natural ingredients reflects consumer preferences for sustainable, eco-friendly products with fewer synthetic chemicals and reduced environmental impact [4]. Herbal cosmeceuticals align with traditional medicine systems like Ayurveda and Traditional Chinese Medicine, which have utilized plant-based remedies for centuries [11]. Plant extracts are especially valuable since they contain beneficial compounds for the skin and can even be sourced from recycled plant waste, making them both effective and sustainable. Key

ingredients like vitamins, antioxidants, and flavonoids help protect the skin, fight aging, and improve its appearance. However, their effectiveness depends on how stable they are and how well they can penetrate the skin. To solve this, modern technologies are being used to improve their delivery and performance [12]. The industry is also blending traditional knowledge of medicinal plants with advanced scientific methods to develop better products. Positioned between cosmetics and pharmaceuticals, cosmeceuticals provide both aesthetic and therapeutic benefits. The popularity of herbal cosmetics is growing rapidly due to their affordability, safety, and eco-friendly nature. Compared to synthetic products, they are often better tolerated by the skin [13].

Although cosmetic products are widely used in everyday life, there is growing concern that some synthetic ingredients may negatively affect respiratory health, especially when inhaled, with more serious risks for sensitive groups such as children, older adults, and people with existing health problems. While natural and organic ingredients, along with green chemistry approaches, appear to be safer alternatives, more research is needed to confirm their safety and to explore how effectively they can replace conventional cosmetic compounds [14]. In light of the growing demand for safer, more sustainable cosmetic alternatives, and given the rich reservoir of bioactive compounds found in medicinal plants, the integration of natural sources with chemical knowledge represents a promising pathway for the development of innovative cosmetic products.

The main goal of this work is the development and analytical characterization of a novel cosmetic product by combining natural bioactive sources with principles of analytical chemistry. Particular emphasis is placed on the qualitative and quantitative evaluation of the formulation, as well as the assessment of its physicochemical properties and stability. To thoroughly investigate this subject, the present memoir is divided into three main chapters:

Chapter One provides general information about bioactive compounds, the importance of medicinal plants, and the formulation of cosmetic products, including the role of natural ingredients in modern cosmetology.

Chapter Two presents the experimental section, detailing the materials, methods, extraction procedures, and formulation steps used in this study.

Chapter Three is dedicated to the results and discussion, where the obtained data are analyzed, interpreted, and compared with existing literature to evaluate the efficacy, stability, and potential applications of the developed cosmetic product.

Through this structured approach, the present work aims to contribute to the development of safe, effective, and scientifically validated plant-based cosmetic formulations.

Chapter I: Literature Review

I.1. Introduction:

Herbal plants have been used in cosmetic practices by many cultures for thousands of years. Ancient Egyptian, Indian and Chinese civilizations were based on the use of plant-derived preparations for skin care, hair treatment and beauty rituals. However, these traditional uses were often not standardized and there was little scientific data on their safety and effectiveness. Modern cosmeceuticals have improved the use of herbal ingredients with advanced methods of extraction, standardization of active compounds and controlled clinical studies. Present formulations also use nanotechnology, microencapsulation and specialized delivery systems to improve the stability and bioavailability of herbal actives. Even though the basis of these applications is still traditional knowledge, modern cosmeceutical science helps to confirm their mechanism of action, concentration and quality of the products and regulatory compliance [15].

I.2. Medicinal plants used in cosmeceuticals:

Natural materials, especially herbs, have been used in human cosmetic rituals since antiquity. The progression of herbal cosmetics from conventional uses to contemporary cosmeceuticals signifies a notable achievement in dermatological research. Contemporary herbal cosmeceuticals integrate traditional wisdom with scientific substantiation, providing efficacious alternatives to synthetic products [16]. Many herbal plants have shown important applications in cosmeceuticals because of their beneficial effects on skin and hair care. Aloe vera is widely known for its moisturizing, wound-healing, and anti-inflammatory properties, mainly due to the presence of polysaccharides and glycoproteins [17]. Turmeric contains curcumin, a powerful antioxidant and anti-inflammatory compound commonly used in skin-brightening and anti-acne products. Green tea is rich in catechins, especially epigallocatechin gallate (EGCG), which provides photoprotective and anti-aging effects. Other widely used plants include Licorice for skin-lightening applications, Centella asiatica for collagen synthesis and wound healing, and Neem for its antibacterial and antifungal activities [18]. An overview of the main cosmeceutical properties and applications of herbal plants is presented in the following figure.

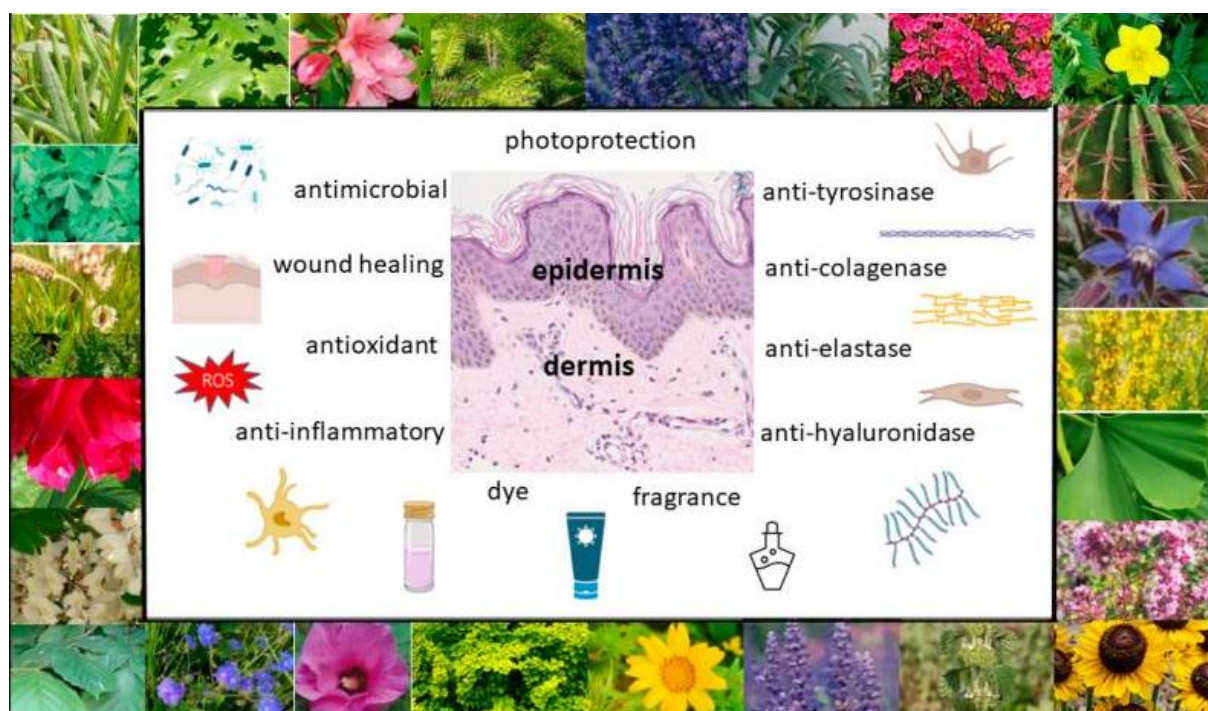


Figure 0.1: The herbal plants used in cosmetic [19].

I.3. Classification of Herbal Cosmetics

I.3.1. Basic Components of Herbal Cosmetics

The formulation of herbal cosmetics requires careful selection and integration of various components to ensure efficacy, stability, and safety. The primary components are described below.

I.3.1.1. Natural Oils and Waxes

Plant-derived oils and waxes serve as essential base materials in herbal cosmetic formulations. Vegetable oils such as almond oil (*Prunus dulcis*), coconut oil (*Cocos nucifera*), and jojoba oil (*Simmondsia chinensis*) provide emollient properties and act as natural carriers for bioactive compounds [19]. Natural waxes, including beeswax, carnauba wax (*Copernicia prunifera*), and candelilla wax (*Euphorbia cerifera*), contribute to product structure and skin protection [20]. An overview of the main herbal cosmetic ingredients, their traditional uses, and active compounds is presented in the following table.

Table 0.1: Major Categories of Herbal Cosmetic Ingredients [16].

Category	Examples	Traditional Uses	Active Compounds
Moisturizing Herbs	Aloe vera, Calendula, Jojoba	Skin hydration, Healing	Polysaccharides, Essential fatty acids
Anti-aging Herbs	Ginkgo biloba, Green tea	Wrinkle reduction, Antioxidant	Flavonoids, Polyphenols
Skin-lightening Herbs	Licorice, Bearberry	Hyperpigmentation treatment	Glabridin, Arbutin
Anti-inflammatory Herbs	Chamomile, Turmeric	Soothing, Calming	Azulene, Curcumin
Antimicrobial Herbs	Tea tree, Neem	Acne treatment, Protection	Terpinen-4-ol, Azadirachtin

I.3.1.2. Botanical Extracts

Plant extracts constitute the core active ingredients in herbal cosmetics. These extracts are obtained through various processes, including hydro-alcoholic extraction, steam distillation, cold pressing, and supercritical fluid extraction. The main extraction methods, along with their advantages, limitations, and efficiencies, are summarized in the following table.

Table 0.2: Comparison of Extraction Methods for Herbal Cosmetic Ingredients [16]

Extraction Method	Advantages	Limitations	Yield Efficiency	Environmental Impact
Solvent Extraction	High yield, Simple	Solvent residues	70-85%	High
Supercritical CO₂	Pure extract, No residue	High cost	85-95%	Low
Ultrasound-assisted	Fast, Efficient	Heat sensitive	75-90%	Medium
Microwave-assisted	Rapid, Less solvent	Equipment cost	80-90%	Low
Enzyme-assisted	Selective, Green	Time consuming	65-80%	Very low

Each extraction method is selected based on the nature of bioactive compounds and their intended cosmetic application [2].

I.3.1.3. Extraction Technologies

Conventional extraction techniques such as maceration, digestion, infusion, percolation, decoction, and Soxhlet extraction are widely used methods for isolating bioactive phytochemicals from plant materials using suitable solvents under room temperature or controlled heating conditions. These methods generally rely on diffusion-driven mass transfer, where plant matrices are immersed or percolated with solvents such as water, ethanol, or their mixtures, allowing phytochemicals like phenolics, flavonoids, and alkaloids to dissolve into the liquid phase. While techniques like maceration and infusion are simple and suitable for heat-sensitive compounds, they often suffer from long extraction times, low efficiency, and high solvent consumption. Methods involving heat, such as decoction and Soxhlet extraction, improve yield but may lead to degradation of thermolabile compounds due to prolonged exposure to elevated temperatures. Overall, although conventional techniques remain widely applied due to their simplicity and low cost, their limitations in terms of time, solvent use, and potential loss of bioactivity have driven the development of more efficient modern extraction technologies [21]. The main steps of the conventional plant extraction process are presented in the following figure.

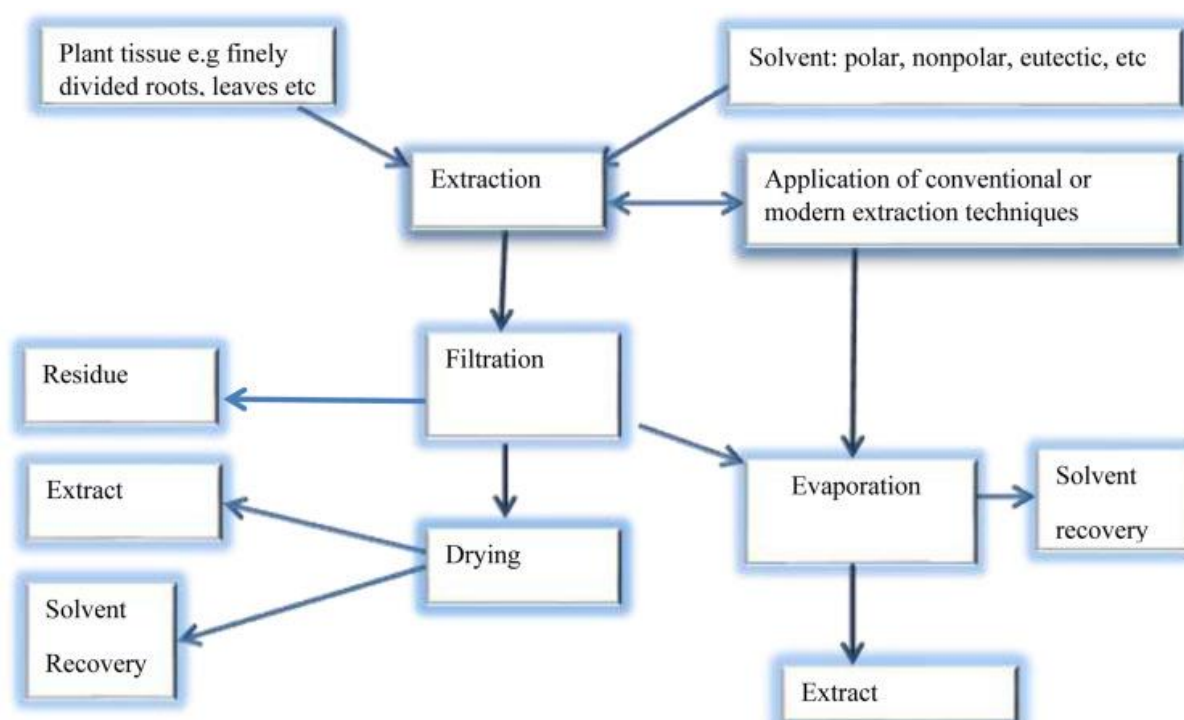


Figure 0.2: General steps involved in plant extraction.

Analytical chemistry seeks accurate, precise, selective, and sensitive measurements while minimizing matrix interferences. Modern methodologies increasingly integrate green chemistry principles to reduce environmental impact and improve operator safety by limiting hazardous reagents, energy use, and waste. In this context, green extraction techniques

emphasize miniaturization, automation, and the use of safe, renewable solvents such as deep eutectic systems. Energy-efficient methods like ultrasound- and microwave-assisted extraction enhance efficiency while lowering environmental impact [22].

1.3.1.4. Natural Preservatives and Antioxidants

Plant-derived preservatives and antioxidants ensure product stability while maintaining the natural character of formulations. Common natural preservatives include essential oils with antimicrobial properties (tea tree, thyme), botanical extracts with antioxidant properties (rosemary, grape seed), and natural organic acids (citric acid, benzoic acid) [23]. An overview of the chemical structures of selected natural antioxidant compounds is presented in the following figure.

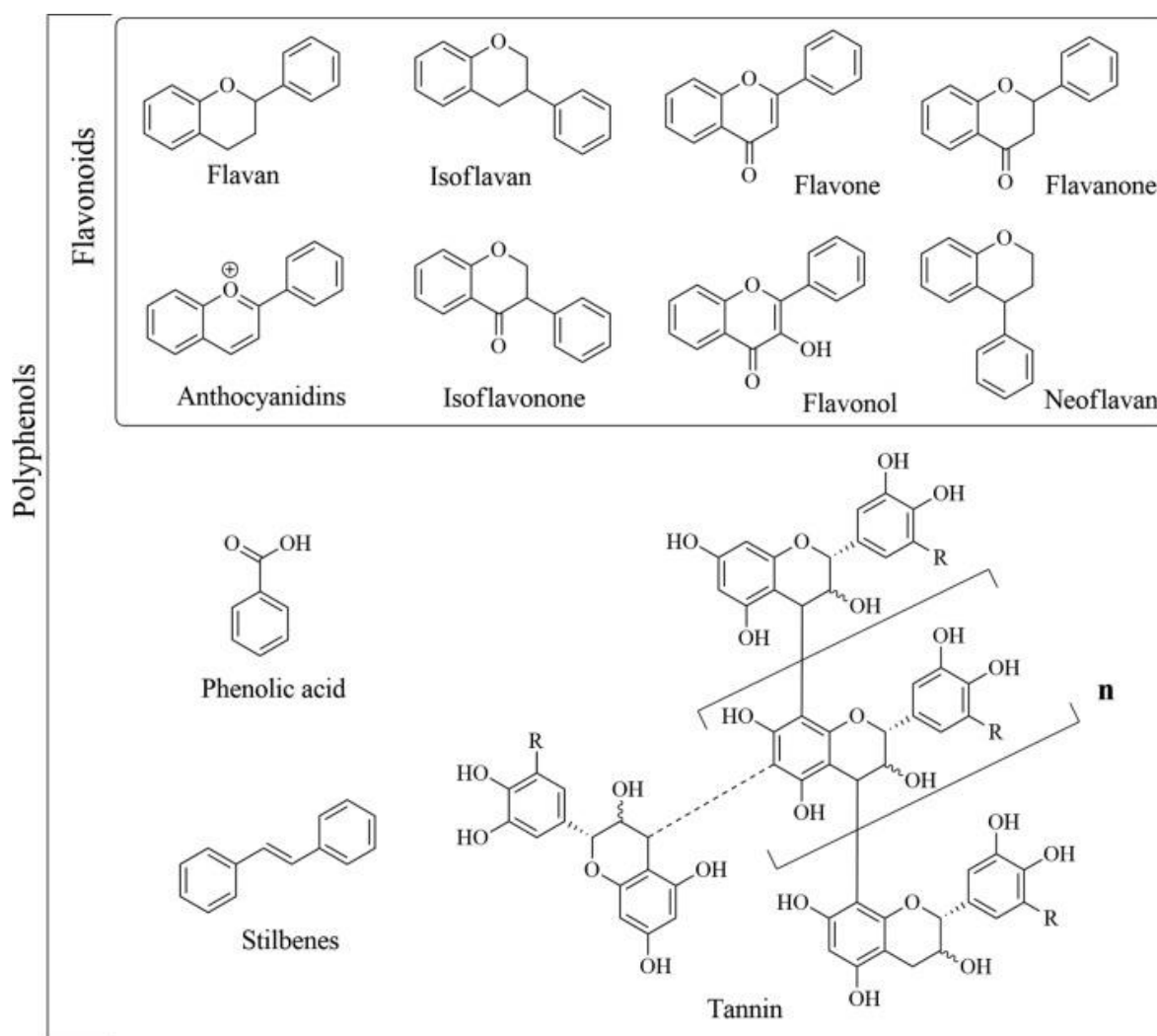


Figure 0.3: Chemical structures of some natural antioxidants [18].

I.3.2. Bioactive Phytochemicals in Herbal Cosmeceuticals

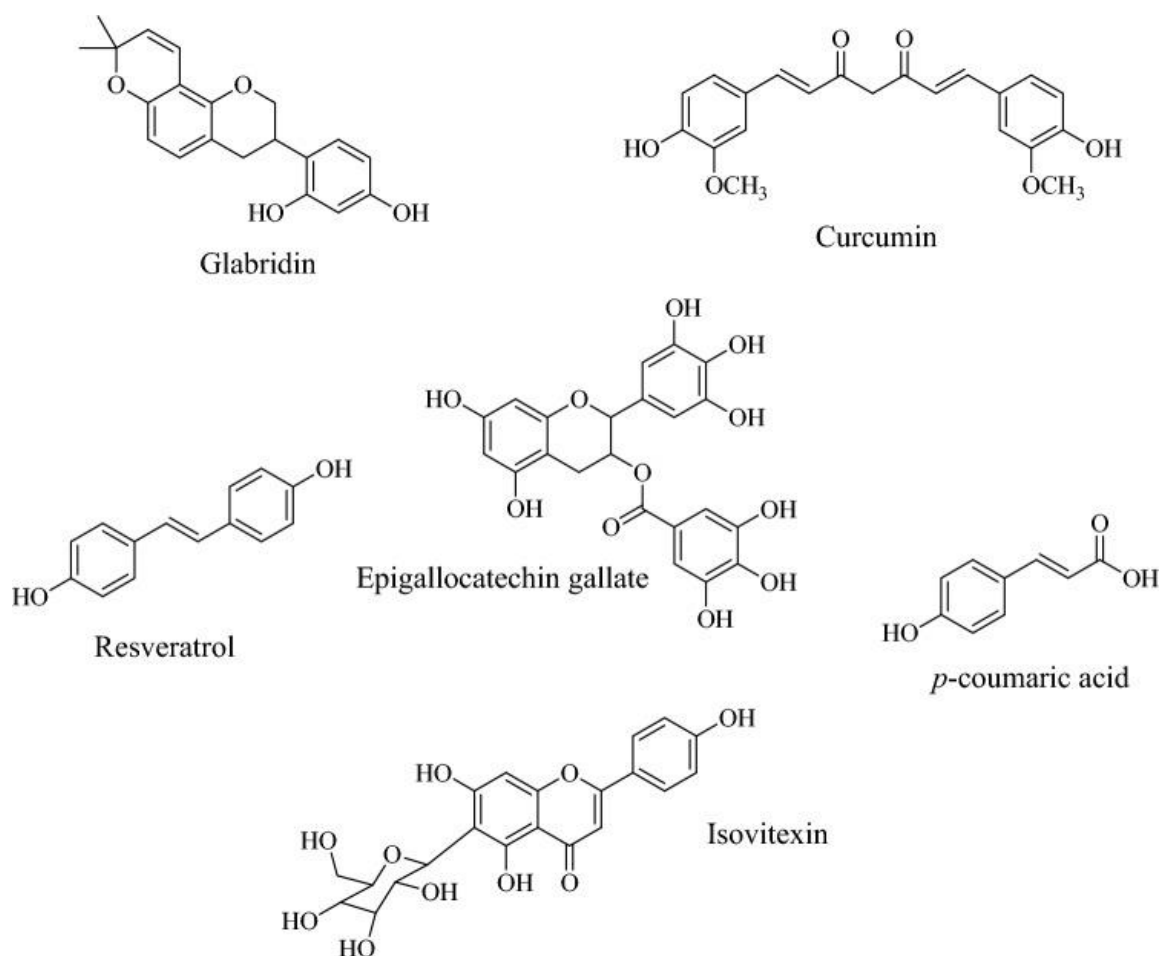


Figure 0.4: Chemical structures of some phytochemicals isolated from plant extracts with cosmeceutical properties [18].

I.3.2.1. Polyphenols and Flavonoids

Polyphenols and flavonoids are abundant phytochemicals valued for antioxidant, anti-inflammatory, and photoprotective effects. Green tea polyphenols, especially EGCG, scavenge free radicals and inhibit collagen-degrading enzymes. Grape-derived resveratrol activates sirtuins and suppresses NF- κ B for anti-aging benefits. Flavonoids (quercetin, kaempferol, rutin) inhibit tyrosinase and enhance skin barrier function [24,25].

I.3.2.2. Terpenoids and Essential Oils

Terpenoids offer diverse cosmeceutical applications. *Centella asiatica* triterpenoids (asiaticoside, madecassoside) promote wound healing by stimulating fibroblast proliferation and collagen production. Ursolic and oleanolic acids provide anti-inflammatory and

antimicrobial effects for acne management. Essential oils like tea tree oil and lavender oil (rich in monoterpenes/sesquiterpenes) exhibit antimicrobial, anti-inflammatory, and aromatherapeutic properties. Limonene and linalool improve skin penetration and product sensory qualities [26,27].

I.3.2.3. Alkaloids and Saponins

Alkaloids, though less common, offer therapeutic benefits. Berberis-derived berberine shows antimicrobial and anti-inflammatory activities for acne and seborrheic skin. Saponins from *Panax ginseng* and *Glycyrrhiza glabra* possess emulsifying, foaming, and biological properties. Ginsenosides improve microcirculation, stimulate collagen synthesis, and reduce wrinkles. Glycyrrhizin and glycyrrhetic acid provide anti-inflammatory and skin-lightening effects via tyrosinase inhibition [28].

I.3.2.4. Vitamins and Minerals

Herbal sources supply essential skin nutrients. Rosehip and citrus fruits provide vitamin C for collagen synthesis and antioxidant protection. Vitamin E (tocopherols) from wheat germ and vegetable oils prevents lipid peroxidation. Provitamin A (β -carotene) from carrots and algae converts to retinol, promoting cell renewal and collagen production. Minerals including zinc, selenium, and copper support enzymatic activity, wound healing, and antioxidant defense [15].

I.3.3. Examples of Most Common Herbal Ingredients

The Mediterranean region is characterized by a rich plant diversity and remarkable biodiversity. Medicinal and aromatic plants have long been used in traditional cuisine as flavoring agents and for the relief and treatment of various health conditions. This high botanical diversity is mainly related to the unique climate and geographical features of the Mediterranean area, which support the growth of indigenous, endemic, and introduced plant species through migration, trade, and historical occupation. An overview of the main Mediterranean medicinal plants and their cosmetic and therapeutic uses is presented in the following figure.



Figure 0.5: Medicinal plants and their derivatives for skin and hair: a Mediterranean perspective of women care [10].

I.3.3.1. Bioactive Compounds in Plants:

Botanical Classification and Active Components Herbal cosmeceuticals derive from diverse botanical families, each contributing unique phytochemical profiles. Diverse cosmeceutical applications of medicinal plants used in our work have been listed, Table 1. Through the extraction and purification of bioactive natural compounds, these plants contribute to the development of novel cosmeceutical formulations. An overview of the plant-based ingredients employed in this work, together with their bioactive constituents and cosmetic relevance, is presented in the following table.

Table 0.3: Plant-Based Bioactive Ingredients for Cosmetic Use.

No	Plant	Picture	Plant/source information	Main bioactive compounds	Main benefits / cosmetic relevance	Refs.
1	Cocos nucifera L.)		Coconut palm provides oil from the kernel of mature coconuts. Virgin coconut oil is obtained by cold pressing or fermentation without chemical refining; in cosmetics it acts as a natural moisturizer and emollient, forming a protective hydration barrier.	Lauric acid; myristic acid; caprylic and capric acids; oleic and linoleic acids; trace polyphenols, flavonoids and tocopherols; monolaurin derivative.	Antimicrobial and antifungal support; emollient and skin-barrier protection; antioxidant and anti-inflammatory contribution; improves skin softness and hydration.	[29,30]
2	Sage (Salvia officinalis L.)		Lamiaceae aromatic herb which provides carnosic acid, carnosol, flavonoids and phenolic/terpene derivatives; sage is valued for antioxidant and anti-inflammatory skin protection.	Rosmarinic, caffeic, ferulic and vanillic acids; luteolin, apigenin, quercetin; thujones, 1,8-cineole, camphor; carnosic acid, carnosol; ursolic and oleanolic acids.	Strong antioxidant core; anti-inflammatory and anti-aging action; antimicrobial support; skin-protective effects and penetration-enhancing terpenes.	[31,32]

3	Lavender (Lavandula spp.)		Lavender essential oil is obtained mainly by steam distillation of flowers and leaves. It is used in cosmetics for calming, antibacterial, antifungal and skin-soothing effects.	Linalool; linalyl acetate; 1,8-cineole; camphor; oxygenated monoterpene fraction.	Calming and aromatherapy effect; antimicrobial activity; anti-inflammatory and anti-irritant skin action; dermal penetration support.	[33,34]
4	Tea tree (Melaleuca alternifolia)		Tea tree oil is obtained from leaves and branches. tea tree hydrosol as a gentler water-based by-product used for acne, irritation and minor skin infections.	Terpinen-4-ol as the main active; more than 100 compounds including monoterpenes, sesquiterpenes and phenolic constituents.	Broad-spectrum antimicrobial and antifungal activity; anti-inflammatory effect; microbial membrane disruption; biofilm suppression.	[35,36]
5	Tea (Camellia sinensis)		Tea leaves are a polyphenol-rich botanical source. green/black tea bioactives used for antioxidant, neurocognitive and cardiometabolic support.	Catechins, especially EGCG; theaflavins and thearubigins; quercetin, kaempferol and rutin; L-theanine; caffeine; vitamins and minerals.	Antioxidant defense; anti-inflammatory effects; neurocognitive support from theanine/caffeine synergy; cardiometabolic and antimicrobial support.	[37]

6	Nut grass (Cyperus rotundus / C. esculentus)		Nut grass exhibits antimicrobial, antifungal and insect-repellent properties. It's very interest in natural hair-removal formulations through possible action on hair follicle activity or hair structure.	Oleic and linoleic acids; vitamin E; phytosterols; sesquiterpenes; monoterpenes such as alpha-pinene; diterpenes; phenolics; flavonoids.	Moisturizing and soothing action; antioxidant protection; possible hair-growth inhibition support; reduced post-depilation irritation; antimicrobial skin protection.	[38]
7	Chamomile (Matricaria chamomilla / Roman chamomile hydrolate)		Roman chamomile hydrolate is a by-product of essential-oil extraction. It calms irritation, supports regeneration and gives mild antibacterial and astringent effects.	Polyphenols; flavonoids; essential-oil fraction; vitamin C; organic acids.	Skin soothing and anti-redness effect; antioxidant and anti-aging protection; mild brightening; hydration and skin-regeneration support.	[39,40]
8	Oryza sativa		rice starch is amylose- and amylopectin-based granules with stability and low swelling ability, useful for functional cosmetic and industrial applications.	Gamma-oryzanol; phenolic compounds and flavonoids; ferulic acid; tocopherols and tocotrienols; phytic acid; essential fatty acids.	Antioxidant and photoprotective support; anti-aging and collagen-support effects; skin brightening; gentle exfoliation; improves	[41,42]

					texture and softness.	
9	Rosemary (<i>Rosmarinus officinalis</i> L.; syn. <i>Salvia rosmarinus</i>)		rosemary flavonoids, phenolic acids and terpenes with antioxidant, anti-inflammatory and antimicrobial properties; nanocarriers can improve topical delivery.	Carnosic acid; carnosol; rosmarinic acid; ursolic acid and other minor polyphenols/diterpene phenols.	ROS scavenging; anti-aging through collagen protection and MMP-1 inhibition; anti-inflammatory and anti-photoaging effects; skin repair support.	[43,44]
10	Clove buds (<i>Syzygium aromaticum</i>)		The eugenol is the main active. Clove oil is used in oral care, food preservation and skincare; encapsulation can improve stability and controlled release.	Eugenol; flavonoids; phenolic acids; tannins; high total phenolic and flavonoid content.	Strong antioxidant activity; antibacterial and anti-acne potential; anti-inflammatory support; natural preservative function in formulations.	[45,46]
11	Aloe vera (<i>Aloe vera</i> / <i>Aloe barbadensis</i>)		Aloe gel is obtained from inside the leaves. its use as a moisturizer, soothing agent and skin healer in creams,	Vitamins A, C, E and B group; enzymes; minerals; acemannan and other polysaccharides;	Hydration and moisture retention; wound-healing support; anti-inflammatory and	[47,48]

			lotions, sunscreens and minor-wound care.	anthraquinones; salicylic acid; amino acids; sterols and fatty acids; lignin and saponins.	antimicrobial action; skin repair and barrier protection.	
12	White henbane (Hyoscyamus albus L.)		calystegine-rich antioxidant extracts with anti-inflammatory, antipyretic and anti-parasitic properties, plus traditional sedative, pain-relieving and antispasmodic use. Safety caution: Hyoscyamus species may contain toxic tropane alkaloids.	Quercetin glycoside; phenylpropanoid derivatives; caffeoyl/feruloyl amides; polyamine derivatives; possible tropane alkaloids in the genus such as hyoscyamine/scopolamine.	Antioxidant and in-vitro anticancer potential; apoptosis-related effects reported in cell studies; sedative/anesthetic traditional relevance through anticholinergic alkaloids. Requires strict safety assessment.	[49,50]
13	Olive oil (Olea europaea)		Olive oil is extracted from the fruit and may be extra virgin, virgin, refined or pomace oil. Quality varies with region, climate and fruit ripeness; it is valued as nourishing and skin-	Oleic, linoleic and palmitic acids; hydroxytyrosol, tyrosol and oleuropein; tocopherols; squalene; sterols; carotenoids.	Deep moisturization and emollience; barrier repair; antioxidant and anti-aging activity; anti-inflammatory and photoprotective support.	[30,51]

			protective.			
14	Castor oil (Ricinus communis)		Castor oil is rich in ricinoleic acid, which know for traditional hair/scalp use, moisturizing skincare use and modern interest for acne, pigmentation, hair loss, psoriasis, skin aging and active-delivery support.	Ricinoleic acid; oleic acid; linoleic acid; trace tocopherols, phytosterols and phenolic compounds.	Strong emollient and moisturizing action; protective lipid film; anti-inflammatory soothing; barrier support; carrier and penetration-enhancing function.	[52,53]
15	Almond oil (Prunus amygdalus / Prunus dulcis)		Almond oil is rich in essential fatty acids. it as anti-inflammatory, nourishing, deeply moisturizing, softening and suitable as a carrier oil for aromatherapy and massage.	Unsaturated fatty acids; oleic acid; linoleic acid; phenolic compounds; tocopherols, mainly alpha-tocopherol.	Skin nourishment; TEWL reduction; barrier restoration; antioxidant and anti-aging support; improves softness, elasticity and texture.	[54,55]

16	Frankincense (<i>Boswellia resin</i> / <i>Boswellia spp.</i>)		Frankincense resin contains anti-inflammatory, antioxidant and antimicrobial compounds. It know for skin protection, healing support and anti-aging action, with nano-delivery systems explored for better stability and efficacy.	n-Octyl acetate; alpha-pinene; limonene; cis/trans-beta-ocimene; n-octanol; linalool; incensole acetate; diterpenes; 1,8-cineole.	Anti-inflammatory and soothing effect; collagen/elastin protection; wound-healing and skin-regeneration support; antimicrobial and anti-aging activity.	[56]
17	Garlic (<i>Allium sativum</i>)		Garlic releases allicin when crushed and contains sulfur compounds, vitamins and minerals. Fermented black garlic as having enhanced antioxidant and photoprotective formulation potential.	Alliin; allicin; diallyl disulfide; diallyl trisulfide; ajoene; vinylthiin; diallyl sulfide; flavonoids; S-allyl cysteine.	Antibacterial and antifungal activity; anti-acne support; antioxidant and anti-aging effects; anti-inflammatory support; wound-healing and photoprotection potential. May irritate sensitive skin.	[57,58]

18	Maerua spp. (<i>M. siamensis</i> / <i>M. oblongifolia</i>)		Maerua oblongifolia, whose tubers are consumed as food and whose roots, bark and leaves are traditionally used for digestive disorders, wounds and dehydration.	Simple phenolics; flavonoid glycosides; blumenol A/vomifolioside; stachydrine-type betaines; azelaic acid; phenethylamide derivative; glycosylated flavonoid ester.	Antioxidant and anti-aging potential; UV/ROS protection; hydration support through osmoprotectant betaines; anti-acne and antimicrobial relevance; barrier stress resistance.	[59,60]
19	Licorice (<i>Glycyrrhiza glabra</i> / <i>Glycyrrhiza</i> spp.)		Licorice root and rhizome extracts are used for anti-inflammatory, skin-lightening and soothing properties in creams, sunscreens, cleansers, makeup and hair-care products.	Glycyrrhizin; glabridin; flavonoids including liquiritin, isoliquiritigenin and licochalcone A; polysaccharides; coumarins and phenolics.	Skin whitening and hyperpigmentation reduction; antioxidant and anti-aging support; photoprotection; hydration; anti-inflammatory and anti-acne effects.	[61]
20	<i>Spinacia oleracea</i> (spinach)		Spinach is a nutrient-rich leafy vegetable belonging to the Amaranthaceae family. It contains high levels of vitamins, minerals,	Spinach is rich in bioactive compounds, mainly phenolic compounds (30–40%), flavonoids (15–25%), chlorophylls (5–	The compounds possess strong antioxidant and anti-inflammatory properties that help protect the skin from	[62]

			magnesium, flavonoids, phenolic acids, and tocopherols, which contribute to its strong antioxidant activity. These bioactive compounds help protect cells from oxidative damage, promote cellular regeneration, and support skin health and anti-aging effects. Studies have confirmed the significant antioxidant potential of spinach extracts, making spinach a valuable natural ingredient for cosmetic and therapeutic applications.	10%), carotenoids (2–5%), and anthocyanins (up to 3%).	oxidative damage, reduce signs of aging, support skin regeneration, improve skin tone, and provide protection against environmental and UV-induced stress. Consequently, spinach is considered a valuable natural ingredient for cosmetic formulations with anti-aging, protective, and skin-rejuvenating effects.	
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I.3.4. Formulation Optimization

I.3.4.1. Stability Enhancement

Advanced stabilization techniques aim to preserve the activity of sensitive herbal compounds. Microencapsulation with natural polymers protects volatile essential oils and plant extracts from environmental degradation. Cyclodextrin inclusion complexes offer molecular-level protection for unstable botanical actives while improving their solubility and bioavailability [63].

I.3.4.2. Synergistic Combinations

Strategic combination of herbal actives produces synergistic effects that enhance overall product efficacy. Blending antioxidant compounds from different botanical sources provides broader protection against oxidative stress. For example, combining green tea polyphenols with natural-source vitamin C demonstrates enhanced photoprotective effects [64].

I.3.5. Quality Control and Standardization

I.3.5.1. Analytical Methods

Advanced analytical techniques ensure consistent quality and standardization of herbal cosmetic formulations. High-performance liquid chromatography coupled with mass spectrometry enables precise quantification of active compounds. Near-infrared spectroscopy provides rapid, non-destructive analysis of raw materials and finished products [65]. An overview of the quality control system applied to herbal cosmetics, from raw material testing to final product evaluation, is presented in the following figure.

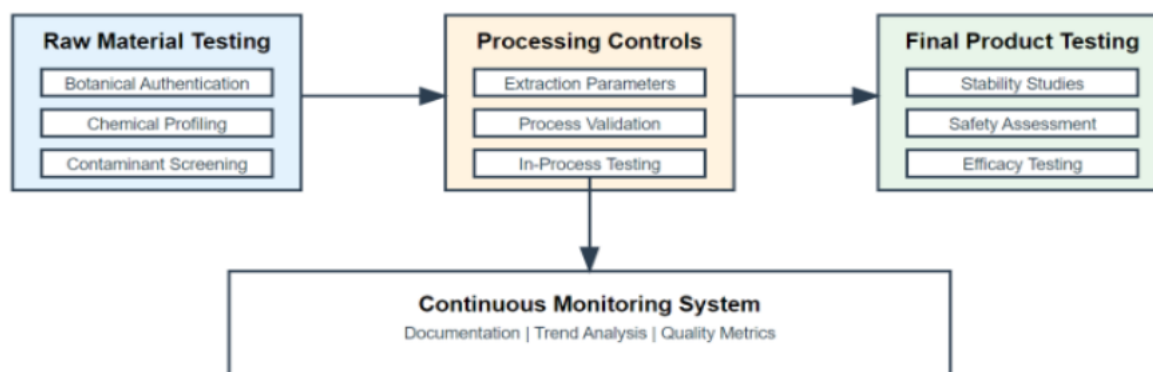


Figure 0.6: Quality Control in Herbal Cosmetics [16].

The key quality control parameters, acceptable limits, testing methods, and testing frequencies for herbal cosmetic ingredients are summarized in the following table.

Table 0.4: *Quality Control Parameters for Herbal Cosmetic Ingredients [16].*

Parameter	Acceptable Range	Testing Method	Frequency of Testing
Heavy Metals	Pb < 10 ppm, Cd < 3 ppm	ICP-MS	Each batch
Microbial Load	TPC <1000 CFU/g	USP method	Each batch
Pesticide Residues	As per WHO limits	GC-MS/LC-MS	Quarterly
Mycotoxins	< 20 ppb	ELISA/HPLC	Bi-annual
Active Markers	± 5% of declared	HPLC/UPLC	Each batch
Moisture Content	5-8%	LOD method	Each batch
pH Value	4.5-7.0	pH meter	Each batch
Stability Studies	ICH guidelines	Multiple methods	Development phase

ICP-MS: Inductively Coupled Plasma Mass Spectrometry; **TPC:** Total Plate Count; **CFU:** Colony Forming Units; **GC-MS:** Gas Chromatography-Mass Spectrometry; **LC-MS:** Liquid Chromatography-Mass Spectrometry; **HPLC:** High Performance Liquid Chromatography; **UPLC:** Ultra Performance Liquid Chromatography; **LOD:** Loss On Drying.

I.3.5.2. Assessment of Stability

Comprehensive stability testing protocols evaluate the long-term stability of herbal formulations under various environmental conditions. Real-time and accelerated stability studies assess changes in physical characteristics, chemical composition, and microbiological quality. Advanced imaging techniques monitor alterations in formulation microstructure during storage [66].

I.3.5.3. Evaluation of Safety and Efficacy

Modern safety assessment protocols combine in vitro methods with clinical studies to evaluate the safety and efficacy of herbal cosmetics. Three-dimensional skin models provide preliminary screening for irritation potential and efficacy. Advanced imaging techniques such as confocal microscopy and optical coherence tomography enable non-invasive evaluation of product effects on skin structure [67]. An overview of the integrated process for herbal

cosmetic development, including extraction, characterization, formulation, and safety evaluation, is presented in the following figure.

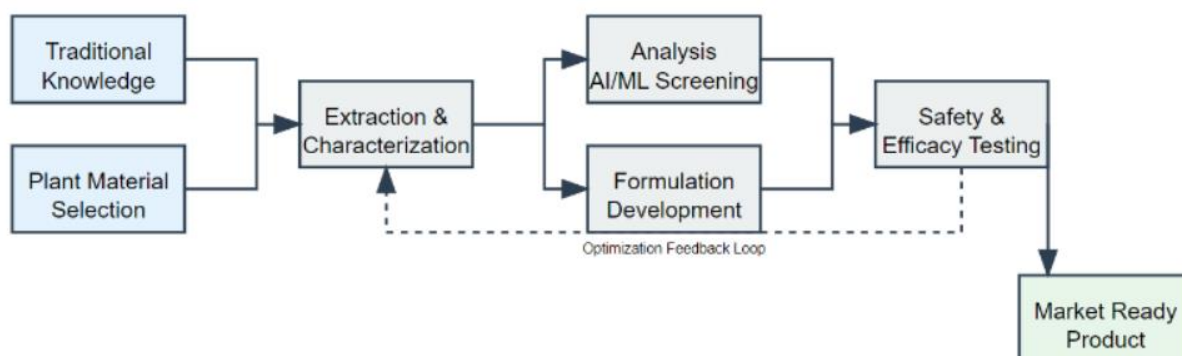


Figure 0.7: Process for Development of Herbal Cosmetics [16].

I.4. Formulation of Natural Cosmetic products

The formulation of natural cosmetic products requires a thorough understanding of the physicochemical properties of ingredients, the selection of appropriate dosage forms, and the optimization of manufacturing processes to ensure stability, efficacy, and safety. Among the most commonly used topical formulations are creams, gels, lotions, and serums, each presenting distinct characteristics and applications in dermal and cosmetic therapy [68].

I.4.1 Creams

Creams are semisolid oil-in-water (O/W) or water-in-oil (W/O) emulsions for external application. Their consistency depends on the oil-to-water ratio. They deliver active ingredients to the skin while providing protective, moisturizing, and therapeutic effects, and are used for dermatological disorders such as acne, eczema, and dryness. O/W creams (e.g., vanishing, foundation, moisturizing) are non-greasy and washable, while W/O creams (e.g., cold, winter, protective) are more emollient and occlusive. Key ingredients include water, oils, waxes, emollients, humectants, preservatives, vitamins, and perfumes [69].

I.4.2 Gels

Gels are semisolid systems with a non-greasy texture, used for effective delivery of active ingredients to the skin. They exhibit non-Newtonian pseudoplastic flow. Hydrogels (e.g., carbopol-based) are common due to their bioadhesion and compatibility. Gelling agents

include gelatin, alginate, cellulose derivatives, and poloxamers. Additional humectants, stabilizers, and preservatives improve product stability [70].

I.4.3 Lotions

Lotions are liquid or semi-liquid preparations for moisturizing, soothing, and treating the skin. Types include simple, therapeutic, suspension, and emulsion lotions. Key ingredients include oils, humectants (glycerin, propylene glycol), emollients, emulsifiers, antioxidants, and preservatives. Their light texture and skin compatibility make them widely used in skincare [71].

I.4.4 Serums

Serums are highly concentrated formulations designed for rapid absorption and deep dermal penetration. They have low viscosity and simplified compositions, often without emulsifiers. Key actives include hyaluronic acid, vitamin C, retinol, AHAs, salicylic acid, and botanical extracts (e.g., aloe vera, green tea, rosemary). Serums target specific concerns such as aging, dehydration, or inflammation [72].

I.4.5 Herbal Cosmetic Soaps

Herbal cosmetic soaps are solid or semi-solid cleansing preparations incorporating plant-derived ingredients such as botanical extracts and essential oils into a soap base. Unlike synthetic soaps, herbal soaps cleanse gently while providing moisturizing, antimicrobial, anti-inflammatory, and antioxidant benefits [13]. Manufacturing involves hot or cold process saponification, where natural oils (coconut, olive, and palm) react with an alkali. Herbal additives (aloe vera, neem, turmeric, lavender, tea tree, chamomile, calendula) are incorporated to target skin conditions such as acne, eczema, dryness, and hyperpigmentation [73]. Key advantages include the absence of harsh detergents, parabens, and artificial fragrances, reducing skin irritation risk. Natural humectants like glycerin help maintain skin hydration [74].

I.5. Evaluation Parameters

I.5.1 Evaluation of Creams

The evaluation of cream formulations includes pH determination (digital pH meter), physical appearance (color, texture, uniformity), spreadability (weight, distance, time factors), saponification value, acid value (free fatty acid content), viscosity (viscometer), homogeneity, ease of removal, dye test (emulsion type identification), after-feel properties (greasiness, smoothness), type of smear, irritancy study (skin reaction), and accelerated stability study (ICH guidelines) [69]

I.5.2 Evaluation of Gels

Gel evaluation encompasses physical parameters (clarity, homogeneity, grittiness), physicochemical parameters (pH, viscosity using Brookfield viscometer), performance parameters (spreadability, extrudability), content and release evaluation (drug content analysis by UV spectrophotometry, in vitro diffusion using Franz diffusion cell), stability studies (physical stability, freeze-thaw cycling), safety evaluation (skin irritation test in vivo), and release kinetics analysis (Zero-order, Higuchi, Korsmeyer-Peppas models)[70].

I.5.3 Evaluation of Lotions

Lotion evaluation includes pH measurement (pH paper or digital meter after 10% dilution), viscosity test (Brookfield viscometer), spreadability (glass slide method), washability (ease of removal with water), organoleptic evaluation (color, odor, appearance, homogeneity), after-feel properties (emollience, slipperiness, absorption rate, residue), type of smear (greasy or non-greasy film), irritancy test (erythema and edema over 24 hours), ease of absorption, and microbial growth test (incubation at 37°C for 72 hours) [75].

I.5.4 Evaluation of Serums

Serum evaluation comprises physical evaluation (color, appearance, homogeneity), physicochemical parameters (pH, viscosity), structural characteristics (globule/particle size analysis, microscopic observation), performance properties (spreadability test, spreadability time), microbiological quality (microbial contamination test), stability studies (physical stability, accelerated stability testing, centrifugation test), safety evaluation (skin irritation test in vivo, heavy metal analysis), functional bioactivity tests (antioxidant activity by DPPH

assay, moisturizing effect by corneometer, melanin assessment by mexameter), and application performance (skin absorption behavior, sensory evaluation) [72].

I.5.5 Evaluation Soaps

Quality and safety are assessed through several parameters. Organoleptic properties (color, odor, appearance, texture) ensure uniformity[13] . pH of a 1% solution should be between 8 and 10 [73]. Foam height and stability are measured by the cylinder shake method [74]. Total fatty matter (TFM) above 75% indicates good cleansing ability, while free alkali content below 0.5% prevents irritation [13,73]. Moisture content is determined by drying at 105°C [74]. Hardness testing ensures durability [73]. Safety includes skin irritation tests (erythema, edema over 24–72 hours) and microbial contamination testing [13,74]. Performance is assessed by cleansing ability and lathering quality (quantity, creaminess, rinsability) [13,73] .

I.6. Safety Standards

I.6.1. International Harmonization

Global regulatory frameworks are evolving to accommodate herbal cosmetic innovations. Harmonization efforts focus on standardizing quality requirements and safety assessments. International collaboration promotes recognition of traditional knowledge while ensuring consumer safety [76].

I.6.2. Safety Assessment

Modern toxicological methods enable safety evaluation of herbal ingredients. In vitro methods using reconstructed human tissues reduce reliance on animal testing. Advanced analytical techniques ensure the absence of contaminants and maintain product integrity [77].

I.6.3. Market Evolution and Consumer Trends

I.6.3.1. Digital Platforms

Digital platforms are transforming herbal cosmetic marketing and consumer education. Augmented reality applications enable virtual product testing and personalized recommendations. Blockchain technology ensures transparency in ingredient sourcing and manufacturing processes [16].

I.6.3.2. Clean Beauty Movement

The clean beauty trend emphasizes minimal, natural formulations with maximum efficacy. Consumer demand drives the development of preservative-free systems using natural antimicrobial compounds. Innovation focuses on maintaining product stability while meeting clean label requirements [78].

Conclusion

The integration of traditional herbal knowledge with modern scientific techniques has revolutionized the development of natural cosmetics, establishing a robust foundation for future innovations. This review has discussed significant progress made in understanding the molecular mechanisms, delivery systems, and clinical efficacy of herbal cosmetics. However, critical challenges remain, particularly in the areas of bioactive compound interactions, long-term safety assessment, and sustainable production practices. Priority areas for future research include elucidating complex molecular pathways through advanced -omics technologies, developing smart delivery systems, and establishing comprehensive safety profiles. Furthermore, the industry must address pressing sustainability challenges through innovative resource management and environmentally conscious production methods. The development of standardized protocols for efficacy validation and safety assessment becomes increasingly crucial as the demand for natural cosmetics continues to grow. Plant-based beauty products are gaining increasing popularity among cosmetic manufacturers due to consumer demand for more sustainable and environmentally friendly lifestyles. Simultaneously, scientific advances have prompted researchers to rigorously evaluate whether these botanicals indeed exert demonstrable cosmetic effects, ensuring that traditional wisdom is supported by evidence-based validation.

Chapter II: Experimental Methodology

II.1. Introduction

The present chapter describes the experimental procedures used for the extraction, preparation, formulation, and evaluation of bioactive compounds derived from medicinal plants for potential cosmetic applications. The work focuses on the development of several topical formulations, including creams, gels, soaps, and chlorophyll-based bioactive materials. The prepared products were evaluated through physicochemical, stability, organoleptic, antioxidant, antimicrobial, and preliminary skin tolerance tests.

The general objective of this study is to investigate the potential use of selected plant-derived bioactive compounds in cosmetic formulations. More specifically, the experimental work aims to:

1. Extract the selected medicinal plants using suitable extraction methods.
2. Formulate different cosmetic products based on natural extracts, oils, and functional active ingredients.
3. Characterize the prepared formulations using physicochemical and stability tests.
4. Evaluate biological activities relevant to cosmetic applications, including antioxidant and antimicrobial activities.
5. Assess the preliminary cosmetic suitability and skin tolerance of the prepared formulations.

II.2. Materials and Reagents

The raw materials used in this study comprised medicinal plant extracts obtained through extraction processes, together with vegetable oils, essential oils, emulsifying agents, gelling agents, humectants, preservatives, and active cosmetic ingredients.

The main plant-based materials included sage extract (*Salvia officinalis*), clary sage extract (*Salvia sclarea*), green tea extract, chamomile extract, rosemary extract, garlic extract (*Allium sativum*), licorice extract (*Glycyrrhiza glabra*), Aloe vera gel, spinach leaves, lavender essential oil (*Lavandula angustifolia*), tea tree essential oil (*Melaleuca alternifolia*), clove essential oil, lemon oil, and Cyperus oil (*Cyperus rotundus*).

The main formulation ingredients included distilled water, glycerin, Shea butter, coconut oil, olive oil, sweet almond oil, castor oil, beeswax, glyceryl stearate, Lanette® O, Carbopol®, Cetareth, zinc oxide, zinc carbonate, potassium alum, sodium bicarbonate, allantoin, salicylic acid, starch, rice powder, bentonite clay, activated charcoal, vitamin E, ethanol, triethanolamine, sodium hydroxide, copper sulfate, hydrochloric acid, and ammonium solution.

II.3. Extraction and Copper Complexation of Chlorophyll from Spinach

Fresh spinach leaves were used as the source material for chlorophyll extraction. A total mass of 600 g of fresh leaves was ground and transferred into two 800 mL beakers. Ethanol was added as the extraction solvent, and the mixture was homogenized manually. The beakers were covered with aluminium foil to protect the pigments from light and placed under continuous stirring for 24 hours [79].

After extraction, the mixture was filtered first through a sieve and then through filter paper to remove plant residues. The filtrate was concentrated using a rotary evaporator to increase the chlorophyll concentration and reduce the solvent volume.

The concentrated extract was redissolved in ethanol containing sodium hydroxide and heated at 60 °C under stirring for 1 hour. Copper sulfate solution was then added after pH adjustment to promote the formation of copper chlorophyll complexes. The reaction mixture was covered with aluminium foil and maintained under continuous stirring for 48 hours.

After complexation, hydrochloric acid was added until neutral pH was reached. Ammonium solution was then introduced to induce precipitation. The precipitate was collected by centrifugation, washed with distilled water, and centrifuged again. The recovered complex was re-extracted with ethanol and dried at 60 °C until complete solvent evaporation. The dried product was then ground into a fine powder. An overview of the process used for the preparation of copper chlorophyllin and the utilization of residual biomass for activated carbon production is presented in the following figure.



Figure 0.1: Schematic of copper chlorophyll and activated carbon preparation.

Part of the obtained copper chlorophyll complex was incorporated into an alginate solution to prepare beads, while the remaining powder was preserved for further characterization and application. An overview of the chlorophyll extraction process and the preparation of chlorophyll-loaded alginate beads through ionic gelation is presented in the following figure.

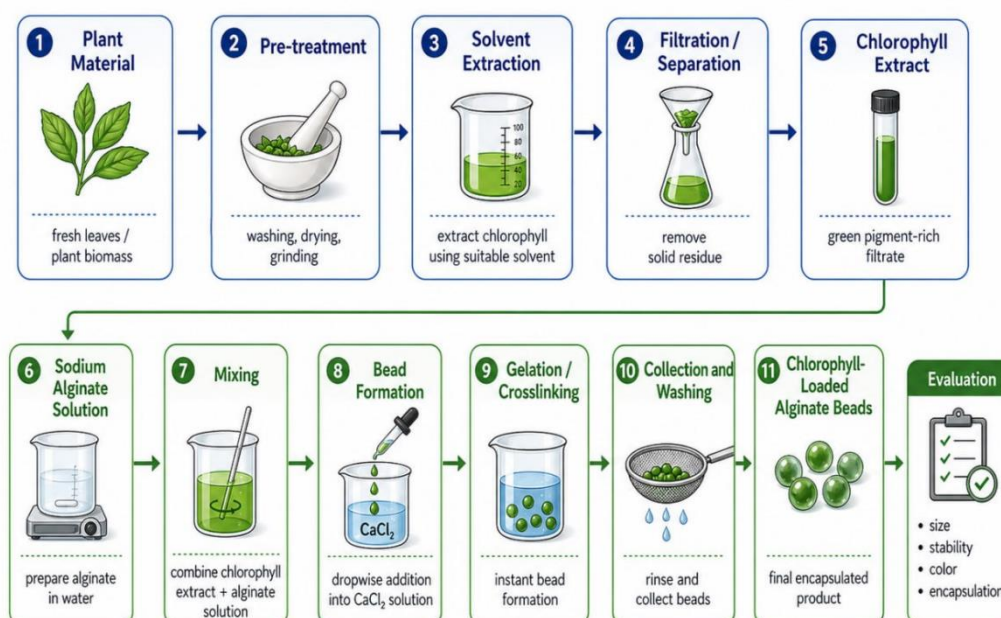


Figure 0.2: Schematic of Chlorophyll extraction and alginate beads preparation.

II.4. Preparation of Cosmetic Formulations

Several cosmetic formulations were prepared in this study. The formulations were designed according to their intended cosmetic function, including antiperspirant, deodorizing, exfoliating, soothing, keratolytic, cleansing, and antimicrobial effects.

To improve the presentation in the thesis, it is better to put the formulation compositions in tables instead of long paragraphs. An overview of the cream formulation process, from the preparation of aqueous and oil phases to product evaluation, is presented in the following figure.

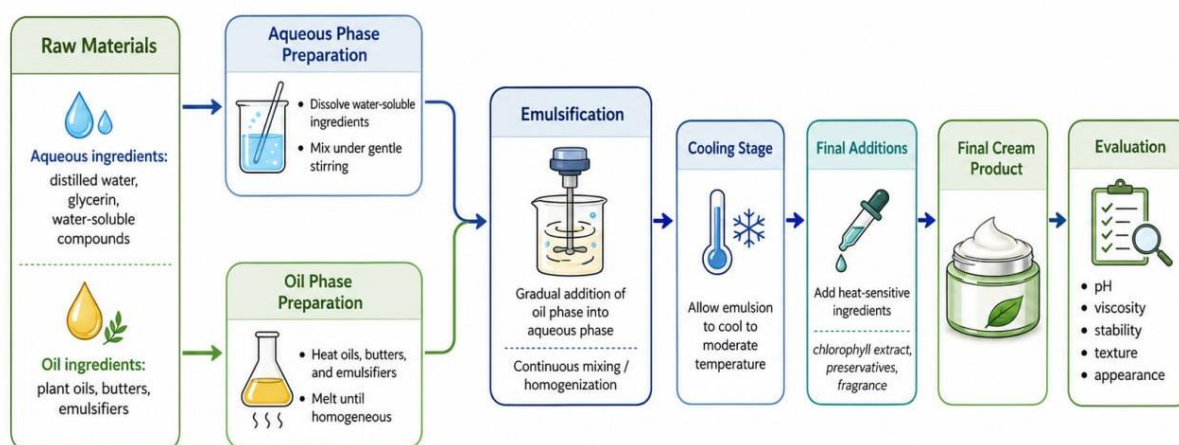


Figure 0.3: Schematic of cream preparation.

II.4.1. Natural Antiperspirant Cream

The chemical antiperspirant cream was prepared as an oil-in-water emulsion composed of an oil phase, aqueous phase, active phase, and additives. The oil phase consisted of vegetable oil (6.9%) (W/W), Shea butter (8%) (W/W), Coconut oil (6%) (W/W), glyceryl stearate (3.5%) (W/W), and Lanette® O (4%) (W/W) as emulsifying and consistency agents. The aqueous phase contained distilled water (42.8%) (W/W), Carbopol® (0.3%) (W/W) as a gelling agent, glycerin (4%) (W/W) as a humectant, sage extract (*Salvia officinalis*, 5%) (W/W), and clary sage extract (*Salvia sclarea*, 3%)(W/W). The active phase included Cetareth (2.5%) (W/W), Zinc oxide (3%) (W/W), allantoin (0.5%) (W/W), and potassium alum (8%) (W/W) as the principal antiperspirant agent. The formulation was further enriched with lavender essential oil (*Lavandula angustifolia*, 1.5%) (W/W), Vitamin E (0.5%) (W/W) as an antioxidant, and a

preservative (Phenexy Ethanol) (0.5%) (W/W) to ensure product stability and microbial protection. After preparation, the cream was transferred into a clean container and stored in a cool, dry place until analysis. Subsequently, several physicochemical and stability tests were performed to evaluate the quality and effectiveness of the final formulation.

STEPS (OIL-IN-WATER EMULSION)		INGREDIENTS	
	1 OIL PHASE Heat oil phase components to 70–75 °C until fully melted.	1. OIL PHASE	% (w/w)
		Vegetable oil	6.9
		Shea butter	8.0
		Coconut oil	6.0
		Glyceryl stearate	3.5
		Lanette® O	4.0
		Total	28.4%
	2 AQUEOUS PHASE - Disperse Carbopol® in distilled water. - Add glycerin and extracts. - Heat to 70–75 °C.	2. AQUEOUS PHASE	% (w/w)
		Distilled water	42.8
		Carbopol®	0.3
		Glycerin	4.0
		Sage extract (<i>Salvia officinalis</i>)	5.0
		Clary sage extract (<i>Salvia sclarea</i>)	3.0
		Total	55.1%
	3 EMULSIFICATION Slowly add the oil phase into the aqueous phase with continuous stirring (high shear homogenization).	3. ACTIVE PHASE	% (w/w)
		Ceteareth	2.5
		Zinc oxide	3.0
		Allantoin	0.5
		Potassium alum	8.0
		Total	14.0%
	4 ACTIVE PHASE Add active ingredients one by one with stirring until uniformly distributed.	4. ADDITIVES	% (w/w)
		Lavender essential oil (<i>Lavandula angustifolia</i>)	1.5
		Vitamin E	0.5
		Preservative	0.5
		Total	2.5%
	5 ADDITIVES - Add lavender essential oil, Vitamin E, and preservative. - Mix gently.		
	6 FINAL PRODUCT - Cool with gentle stirring until room temperature is reached. - Transfer into a clean container. - Store in a cool, dry place.		
		GRAND TOTAL	100.0%

Figure 0.4: Preparation of antiperspirant underarm cream.

II.4.2. Antiperspirant Foot Cream

The antiperspirant foot cream was formulated using an oil phase, aqueous phase, and active phase to obtain a stable emulsion with deodorizing and antimicrobial properties. The oil phase consisted of Beeswax (14.6%) (W/W), Shea butter (4%) (W/W), Coconut oil (3%) (W/W), and glyceryl stearate (1.75%) (W/W) as an emulsifying agent. The aqueous phase contained distilled water (10.9%) (W/W), glycerin (2.5%) (W/W) as a moisturizing agent, and sage extract (*Salvia officinalis*, 4%) (W/W). The active phase included Zinc oxide (1.5%) (W/W), sodium bicarbonate (0.25%) (W/W), sage powder (2%) (W/W), and potassium alum (4%) (W/W) as antiperspirant and deodorizing agents. The formulation was supplemented with a preservative (Phenexy Ethanol) (0.5%) (W/W), lavender essential oil (*Lavandula angustifolia*, 0.5%) (W/W), and tea tree essential oil (*Melaleuca alternifolia*, 0.5%) (W/W) to enhance

antimicrobial activity and provide a pleasant fragrance. After preparation, the cream was transferred into a clean container and stored in a cool and dry place until further analysis. Subsequently, several physicochemical and stability tests were performed to evaluate the quality and effectiveness of the final formulation.

II.4.3. Pre-Depilatory Exfoliating Cream

The pre-depilatory exfoliating cream was designed to prepare the skin before hair removal. It was formulated to provide exfoliating, cleansing, soothing, and impurity-absorbing effects. The oil phase consisted of Shea butter (10%) (W/W), Coconut oil (6%) (W/W), Beeswax (3%) (W/W), lemon oil (3.5%) (W/W), glyceryl stearate (3%) (W/W), and Lanette® O (3%) (W/W) as emulsifying and consistency agents. The aqueous phase contained distilled water (33.7%) (W/W), glycerin (4%) (W/W) as a humectant, and Carbopol® (0.3%) (W/W) as a gelling agent. The active phase included Cetareth (2%) (W/W), green tea extract (4%) (W/W), chamomile extract (3%) (W/W), starch (6%) (W/W), coarse rice powder (8%) (W/W) as a natural exfoliating agent, bentonite clay (2%) (W/W), zinc carbonate (3%) (W/W), allantoin (0.5%) (W/W), rosemary extract (0.3%) (W/W), tea tree essential oil (2%) (W/W), clove essential oil (2%) (W/W), Vitamin E (0.2%) (W/W), and a preservative (Phenexy Ethanol) (0.5%) (W/W). The formulation was designed to exfoliate dead skin cells, absorb excess impurities, soothe skin irritation, and prepare the skin for effective hair removal. The presence of coarse rice powder provides a physical exfoliating effect, while chamomile, green tea, and allantoin contribute to soothing and skin-conditioning properties.

After preparation, the cream was transferred into a clean container and stored in a cool and dry place until further analysis. Subsequently, several physicochemical and stability tests were performed to evaluate the quality and effectiveness of the final formulation.

II.4.4. Post-Depilatory Soothing Cream

The post-depilatory soothing cream was formulated as an oil-in-water emulsion intended to calm the skin after hair removal. The formulation contained Shea butter, Cyperus oil, coconut oil, beeswax, glyceryl stearate, Lanette® O, distilled water, glycerin, Carbopol®, Cetareth, green tea extract, chamomile extract, starch, bentonite clay, zinc carbonate, allantoin, rosemary extract, vitamin E, tea tree essential oil, clove essential oil, and preservative(Phenexy Ethanol).

This formulation was designed to moisturize the skin, reduce post-epilation discomfort, provide antimicrobial protection, and improve the sensory quality of the treated area.

II.4.5. Wart Removal Cream

The wart removal cream was formulated using an oil phase and aqueous phase containing keratolytic, antimicrobial, and skin-conditioning ingredients. The formulation included beeswax, sweet almond oil, tea tree essential oil, distilled water, garlic extract, green tea extract, salicylic acid, glycerin, vitamin E, and preservative(Phenexy Ethanol).

Salicylic acid was used as the principal keratolytic ingredient, while tea tree oil, garlic extract, and green tea extract were included for their functional biological properties. The formulation was stored in a clean container under appropriate conditions until further evaluation.

II.4.6. Antiperspirant Foot Gel

The antiperspirant foot gel was prepared as a hydroalcoholic gel containing ethanol, distilled water, Carbopol®, Aloe vera gel, glycerin, camphor, allantoin, sage extract, clary sage extract, triethanolamine, lavender essential oil, and preservative(Phenexy Ethanol).

Carbopol® was used as the gelling agent, while triethanolamine was added to neutralize the polymer and stabilize the gel structure. Aloe vera gel and glycerin were incorporated to improve hydration and skin feel.

II.4.7. Herbal Cosmetic Soaps

Two herbal charcoal soap formulations were prepared.

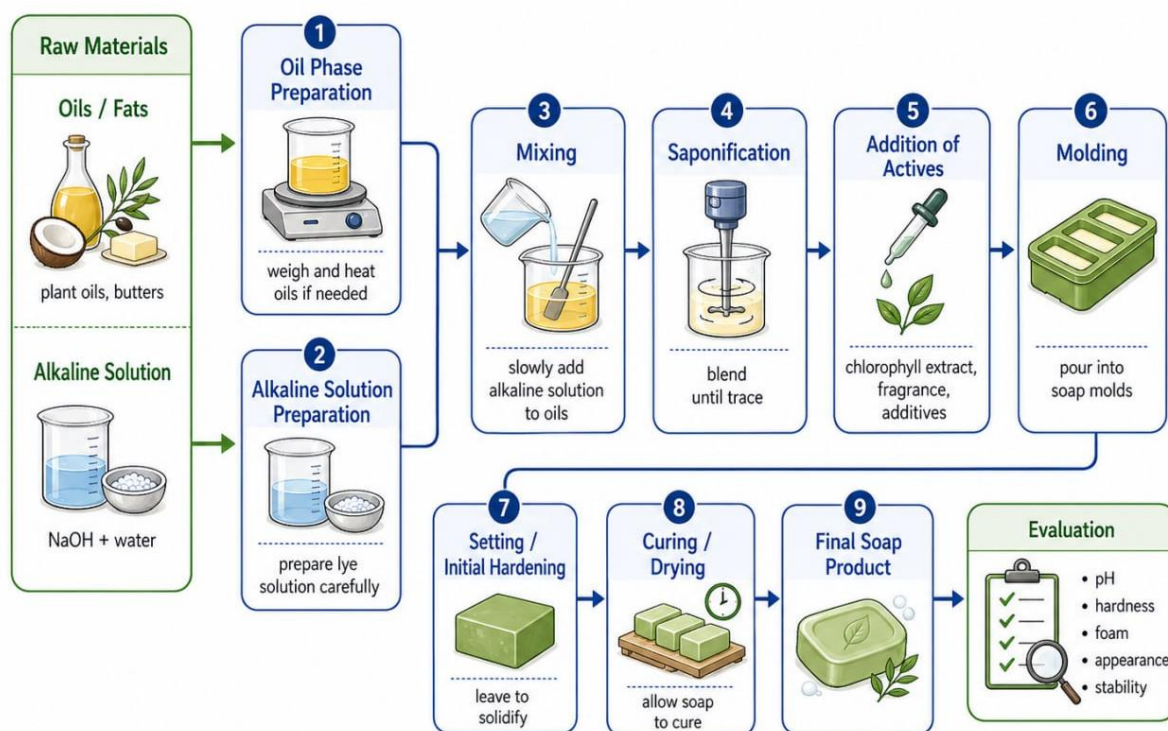


Figure 0.5: Schematic of soap preparation.

II.4.7.1. Olive Oil-Based Herbal Charcoal Soap

The first soap formulation was based mainly on olive oil as the saponifiable base. It was enriched with activated charcoal, licorice extract, Aloe vera gel, tea tree essential oil, salicylic acid, chamomile extract, and fragrance.

After preparation, the soap mixture was poured into clean molds and left undisturbed for 48 hours to harden. The soaps were then removed from the molds and cured in open air for 8 weeks before use.

II.4.7.2. Multi-Oil Nourishing Charcoal Soap

The second soap formulation was prepared using a blend of olive oil, coconut oil, castor oil, sweet almond oil, and Shea butter. Activated charcoal, licorice extract, Aloe vera gel, tea tree essential oil, salicylic acid, chamomile extract, and fragrance were added as functional ingredients.

The curing process was carried out under the same conditions as the first soap formulation.

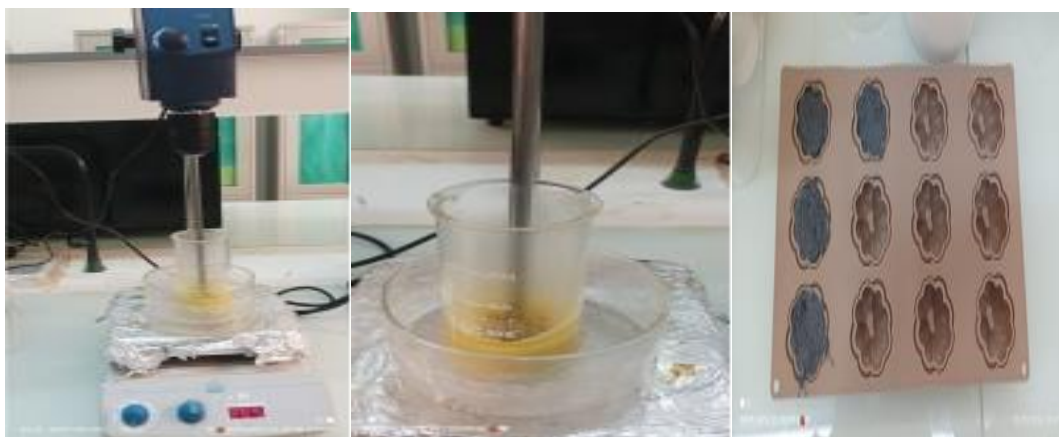


Figure 0.6: Step preparation of soap.

II.5. Characterization of Chlorophyllin Complexes

The synthesized chlorophyllin complexes were characterized by UV–Visible spectrophotometry and antioxidant activity assessment. Absorbance measurements at selected wavelengths were used to quantify chlorophyll a, chlorophyll b, and total chlorophyll contents. The formation of copper chlorophyllin complexes was monitored spectrophotometrically using copper sulfate as a reference standard. Furthermore, the antioxidant capacity of the obtained complexes was determined through the DPPH free-radical scavenging assay.

II.5.1. Determination of Chlorophyll in Plant Extract by UV–Visible Spectroscopy

1. Principle

Chlorophyll pigments (chlorophyll a and b) absorb strongly in the red region of the visible spectrum. Their concentrations can be quantified by measuring absorbance at specific wavelengths (typically 663 nm and 645 nm) and applying standard equations

2. Materials and Equipment

Reagents

- Acetone (80% v/v in distilled water) *or* 95% ethanol
- Distilled water
- Fresh plant leaves (spinach or any green plant)

Equipment

- UV–Visible spectrophotometer
- Quartz or glass cuvettes (1 cm path length)
- Mortar and pestle
- Analytical balance
- Centrifuge
- Filter paper (Whatman No.1)
- Volumetric flasks (25 mL, 50 mL)
- Pipettes

3. Sample Preparation

1. Weigh the sample

- Accurately weigh 0.5 g of fresh plant leaves.
- Cut into small pieces.

2. Homogenization

- Grind the leaves in a mortar with 10–20 mL of 80% acetone until fully homogenized.

3. Extraction

- Transfer the mixture to a centrifuge tube.
- Rinse the mortar with additional acetone and combine extracts.

4. Centrifugation

- Centrifuge at 4000 rpm for 10 minutes.
- Collect the clear supernatant.

(Alternatively, filter using Whatman filter paper if centrifuge is unavailable.)

5. Volume Adjustment

- Transfer extract to a volumetric flask and make up to a known final volume (e.g., 25 mL) with 80% acetone.

4. Spectrophotometric Measurement

1. Turn on the UV–Vis spectrophotometer and allow it to warm up.
2. Set wavelength to:
 - **663 nm** (for chlorophyll a)
 - **645 nm** (for chlorophyll b)

3. Use **80% acetone as blank**.
4. Fill cuvette with plant extract.
5. Record absorbance values:
 - A₆₆₃
 - A₆₄₅

5. Calculations (Arnon Equations) [80]

For 80% acetone extract:

$$\text{Chlorophyll } a \text{ (mg/L)} = 12.7 \times A_{663} - 2.69 \times A_{645}$$

$$\text{Chlorophyll } b \text{ (mg/L)} = 22.9 \times A_{645} - 4.68 \times A_{663}$$

$$\text{Total Chlorophyll (mg/L)} = 20.2 \times A_{645} + 8.02 \times A_{663}$$

Conversion to mg/g Fresh Weight:

$$\text{Chlorophyll (mg/L)} = \frac{C \times V}{1000 \times W}$$

Where:

- C = concentration from equation (mg/L)
- V = final extract volume (mL)
- W = weight of plant sample (g)

II.6. Physicochemical Evaluation of the Prepared Formulations

The prepared creams, gels, and soaps were evaluated using several physicochemical and organoleptic tests in order to assess their quality, appearance, homogeneity, pH, solubility behavior, and preliminary stability.

II.6.1. Organoleptic Evaluation

The organoleptic properties of the prepared formulations were evaluated by visual and sensory examination. The parameters observed included appearance, color, texture, odor, homogeneity, consistency, and signs of phase separation.

A small amount of each formulation was gently rubbed between the thumb and index finger to assess smoothness, spreadability, greasiness, stiffness, and the possible presence of coarse particles [81] .

II.6.2. Acidity test

In the Acidity test, a small amount of each sample was placed in a graduated tube, followed by the addition of a few drops of bromothymol blue indicator. The observed color change was used to estimate the acidic or alkaline character of the formulation.

II.6.3. pH Measurement

The pH of the prepared formulations was evaluated using pH indicator paper. The pH indicator paper was immersed directly into the sample, and the resulting color was compared with the standard pH scale.

II.6.4. Solubility and Dispersion Test

The solubility behavior of the prepared formulations was evaluated by placing a fixed amount of each sample into separate test tubes, followed by the addition of 2 mL of solvent. The mixtures were shaken thoroughly, and the degree of dissolution, dispersion, and homogeneity was visually examined.

II.6.5. Centrifugation Test

After the solubility test, the samples were subjected to centrifugation for 10 minutes to evaluate phase separation behavior. After centrifugation, the samples were visually examined to determine whether they remained homogeneous or separated into different phases. This test was used as a preliminary indicator of physical stability.

II.6.6. Foam test

The foaming ability of the prepared soaps was evaluated by dissolving 0.1 g of each soap sample in separate test tubes containing 10 mL of distilled water. The mixtures were vigorously shaken until stable foam was formed. The foam height was then measured to assess the foaming capacity of each formulation.

II.6. Stability Evaluation

The stability of the prepared cosmetic formulations was monitored over an observation period of approximately eight weeks. During this period, the formulations were examined for changes in color, odor, texture, pH, viscosity, homogeneity, and phase separation [82,83].

II.7. Antioxidant Activity Evaluation

The antioxidant activity of selected extracts and formulations was evaluated using DPPH and ABTS radical scavenging assays.

II.7.1. DPPH Radical Scavenging Assay

The DPPH assay was used to evaluate the free radical scavenging capacity of the tested samples. Different concentrations of each sample were prepared in methanol. Then, 2 mL of 0.1 mM DPPH solution was added to 1 mL of each sample solution. The mixtures were stirred and incubated for 1 hour in the dark at room temperature.

After incubation, the absorbance was measured at 517 nm using a UV–visible spectrophotometer. A control solution containing methanol and DPPH solution was prepared under the same conditions. The radical scavenging activity was calculated based on the decrease in absorbance compared with the control using ascorbic acid[84] .

The percentage inhibition was calculated using the following equation:

$$\% \text{ Inhibition} = \frac{A_0 - A_1}{A_0} \times 100$$

where A_0 is the absorbance of the control and A_1 is the absorbance of the sample.

Chapter III: Results and Discussion

III.1. Introduction

This chapter presents and discusses the experimental results obtained during the extraction, characterization, and application of bioactive compounds derived from natural plant sources for cosmetic and nutraceutical purposes. The study focused on the valorization of selected natural ingredients, particularly *Salvia officinalis* (sage) extract, activated charcoal, and chlorophyllin, and their incorporation into innovative products including an antiperspirant underarm cream, herbal soaps, and a chlorophyllin-based dietary supplement.

The findings presented in this chapter provide an assessment of the extraction procedures, formulation development, and quality characteristics of the resulting products.

III.2. Creams formulation characterization

III.2.1. Oil/Aqueous Phase Balance

For an **oil-in-water emulsion O/W**, the aqueous phase is the continuous phase, while the oil phase is dispersed as droplets. Therefore, the aqueous phase is generally higher than the oil phase. A practical academic way to present the balance is:

$$\text{Total formulation} = \text{Oil phase} + \text{Aqueous phase} + \text{Active phase} + \text{Additives} = 100\%$$

The oil phase was mainly composed of lipophilic ingredients such as oils, butters, waxes, and oil-soluble emulsifiers. The aqueous phase contained distilled water, hydrophilic extracts, humectants, and gelling agents. The balance between both phases was adjusted to maintain emulsion stability, suitable viscosity, good spreadability, and homogeneous dispersion of active ingredients. An overview of the organoleptic characteristics and visual appearance of the formulated cosmetic products prior to physicochemical testing is provided in the following table.

Table 0.1: Visual appearance of the prepared cosmetic formulations before physicochemical testing;

Antiperspirant Foot Gel	Post-Depilatory Soothing Cream	Pre-Depilatory Exfoliating Cream
		
Natural Antiperspirant Cream	Antiperspirant Foot Cream	Wart Removal Cream
		

A/ Natural Antiperspirant Cream Formulation

Phase balance:

Oil phase = **28.4%**

Aqueous phase = **55.1%**

Active phase = **14.0%**

Additives = **2.5%**

Total = **100%**

This is a relatively balanced O/W cream, because the aqueous phase is higher than the oil phase. A detailed description of the ingredients, their phase allocation, concentrations, and technological functions in the natural antiperspirant cream is presented in the following table.

Table III.1. Composition, phase distribution, and functional role of ingredients in the chemical antiperspirant cream.

Phase	Ingredient	Percentage (%)	Role in formulation
Oil phase	Vegetable oil	6.9	Emollient; improves skin softness and spreadability

Oil phase	Shea butter	8.0	Emollient and consistency agent; improves cream body
Oil phase	Coconut oil	6.0	Emollient; contributes to skin-conditioning and texture
Oil phase	Glyceryl stearate	3.5	Emulsifier and consistency agent; helps stabilize the O/W emulsion
Oil phase	Lanette® O	4.0	Fatty alcohol-based consistency agent; improves viscosity and emulsion stability
Aqueous phase	Distilled water	42.8	Main aqueous vehicle and continuous phase
Aqueous phase	Carbopol®	0.3	Gelling and viscosity-building agent
Aqueous phase	Glycerin	4.0	Humectant; improves hydration and prevents drying
Aqueous phase	Sage extract	5.0	Botanical active; deodorizing, soothing, and cosmetic functional ingredient
Aqueous phase	Clary sage extract	3.0	Botanical active; contributes to fragrance and skin-conditioning properties
Active phase	Ceteareth	2.5	Non-ionic emulsifier/surfactant; improves emulsion stability
Active phase	Zinc oxide	3.0	Protective, absorbent, and soothing agent
Active phase	Allantoin	0.5	Skin-conditioning, soothing, and skin-protecting agent; these functions are recognized in cosmetic ingredient references such as CosIng/CIR reports.
Active phase	Potassium alum	8.0	Main antiperspirant/astringent active; helps reduce perspiration-related moisture
Additives	Lavender essential oil	1.5	Fragrance and antimicrobial-supporting essential oil
Additives	Vitamin E	0.5	Antioxidant; protects lipophilic ingredients from oxidation
Additives	Preservative	0.5	Protects the formulation against microbial contamination

The formulation contains a suitable amount of oil phase to provide creaminess and skin feel, while the higher aqueous phase supports an O/W emulsion structure. The combination of glyceryl stearate, Lanette® O, and Cetareth helps stabilize the interface between oil and water phases.

B/ Antiperspirant Foot Cream Formulation

A detailed overview of the ingredients, their concentrations, phase allocation, and technological functions in the antiperspirant foot cream formulation is provided in the following table.

Table 0.2: Composition, phase distribution, and functional role of ingredients in the antiperspirant foot cream.

Phase	Ingredient	Original percentage (%)	Role in formulation
Oil phase	Beeswax	14.6	Structuring agent; increases hardness and occlusive character
Oil phase	Shea butter	4.0	Emollient; improves skin softness and cream texture
Oil phase	Coconut oil	3.0	Emollient; contributes to smooth application
Oil phase	Glyceryl stearate	1.75	Emulsifier and consistency agent
Aqueous phase	Distilled water	60.9	Aqueous vehicle
Aqueous phase	Glycerin	2.5	Humectant; improves skin hydration
Aqueous phase	Sage extract	4.0	Botanical active; deodorizing and skin-conditioning ingredient
Active	Zinc oxide	1.5	Absorbent, protective, and soothing agent

phase			
Active phase	Sodium bicarbonate	0.25	Deodorizing agent; helps neutralize odor-related acidity
Active phase	Sage powder	2.0	Botanical powder; contributes to deodorizing and absorbent properties
Active phase	Potassium alum	4.0	Antiperspirant/astringent active
Additives	Preservative	0.5	Microbial protection
Additives	Lavender essential oil	0.5	Fragrance and antimicrobial-supporting ingredient
Additives	Tea tree essential oil	0.5	Fragrance and antimicrobial-supporting ingredient

The formulation is more aqueous and may form a softer O/W cream, the oil and wax content becomes very high, which may produce a thick balm-like texture rather than a classical cream.

C/ Pre-Depilatory Exfoliating Cream Formulation

Phase balance:

Oil phase = **28.5%**

Aqueous phase = **38.0%**

Active/additive phase = **33.5%**

Total = **100%**

This formulation contains a relatively high active/solid phase because of rice powder, starch, clay, and zinc carbonate. A detailed overview of the ingredients, their concentrations, phase allocation, and technological functions in the pre-depilatory exfoliating cream formulation is presented in the following table.

Table 0.3: Composition, phase distribution, and functional role of ingredients in the pre-depilatory exfoliating cream.

Phase	Ingredient	Percentage (%)	Role in formulation
Oil phase	Shea butter	10.0	Emollient; improves softness and skin conditioning
Oil phase	Coconut oil	6.0	Emollient; improves spreadability
Oil phase	Beeswax	3.0	Structuring agent; increases viscosity and stability
Oil phase	Lemon oil	3.5	Fragrance and sensory ingredient
Oil phase	Glyceryl stearate	3.0	Emulsifier and consistency agent
Oil phase	Lanette® O	3.0	Consistency agent; improves emulsion body
Aqueous phase	Distilled water	33.7	Main aqueous vehicle
Aqueous phase	Glycerin	4.0	Humectant; improves skin hydration
Aqueous phase	Carbopol®	0.3	Gelling agent; improves viscosity and suspension of particles
Active phase	Ceteareth	2.0	Emulsifier/surfactant; supports emulsion stability
Active phase	Green tea extract	4.0	Botanical active; antioxidant and skin-conditioning ingredient
Active phase	Chamomile extract	3.0	Soothing botanical extract
Active	Starch	6.0	Absorbent and texture modifier

phase			
Active phase	Coarse rice powder	8.0	Natural exfoliating agent
Active phase	Bentonite clay	2.0	Absorbent; helps remove impurities and improve texture
Active phase	Zinc carbonate	3.0	Absorbent and protective powder
Active phase	Allantoin	0.5	Soothing and skin-protecting agent
Active phase	Rosemary extract	0.3	Botanical antioxidant-supporting ingredient
Additives	Tea tree essential oil	2.0	Fragrance and antimicrobial-supporting ingredient
Additives	Clove essential oil	2.0	Fragrance and antimicrobial-supporting ingredient
Additives	Vitamin E	0.2	Antioxidant for the oil phase
Additives	Preservative	0.5	Microbial protection

The oil phase provides emollience and improves skin comfort during exfoliation. The aqueous phase supports an O/W emulsion structure, while Carbopol® improves viscosity and helps suspend exfoliating particles. Because the solid phase is high, the formulation may require strong mixing to ensure homogeneous particle dispersion and prevent sedimentation.

D/ Post-Depilatory Soothing Cream Formulation

Phase balance:

Oil phase = **28.5%**

Aqueous phase = **38.0%**

Active/additive phase = **33.5%**

Total = **100%**

A detailed overview of the ingredients, their concentrations, phase allocation, and technological functions in the post-depilatory soothing cream formulation is presented in the following table.

Table 0.4: Composition, phase distribution, and functional role of ingredients in the post-depilatory soothing cream.

Phase	Ingredient	Percentage (%)	Role in formulation
Oil phase	Shea butter	6.0	Emollient; softens and protects the skin
Oil phase	Cyperus oil	7.5	Botanical oil; skin-conditioning ingredient
Oil phase	Coconut oil	6.0	Emollient; improves application and texture
Oil phase	Beeswax	3.0	Structuring agent; increases viscosity
Oil phase	Glyceryl stearate	3.0	Emulsifier and consistency agent
Oil phase	Lanette® O	3.0	Consistency agent; supports emulsion stability
Aqueous phase	Distilled water	33.7	Main aqueous vehicle
Aqueous phase	Glycerin	4.0	Humectant; improves hydration
Aqueous phase	Carbopol®	0.3	Gelling agent; improves viscosity and stability
Active phase	Ceteareth	2.0	Emulsifier/surfactant
Active phase	Green tea extract	4.0	Botanical active; antioxidant and skin-conditioning ingredient

Active phase	Chamomile extract	3.0	Soothing extract
Active phase	Starch	6.0	Absorbent and texture modifier
Active phase	Bentonite clay	10.0	Absorbent and viscosity-increasing mineral ingredient
Active phase	Zinc carbonate	3.0	Absorbent and protective powder
Active phase	Allantoin	0.5	Soothing and skin-protecting agent
Active phase	Rosemary extract	0.3	Botanical antioxidant-supporting ingredient
Additives	Vitamin E	0.2	Antioxidant
Additives	Tea tree essential oil	2.0	Fragrance and antimicrobial-supporting ingredient
Additives	Clove essential oil	2.0	Fragrance and antimicrobial-supporting ingredient
Additives	Preservative	0.5	Microbial protection

This formulation has the same general phase ratio as the pre-depilatory cream but contains a higher amount of bentonite clay. This may increase viscosity and absorbency. The oil phase improves post-depilation skin comfort, while the aqueous phase and humectant contribute to hydration. The balance between oil, water, and powders is important to avoid excessive stiffness or poor spreadability.

E/ Wart-Care Keratolytic Cream Formulation

Phase balance:

Oil phase = **13.0%**

Aqueous phase/active hydrophilic phase = **85.7%**

Additives = **1.3%**

Total = **100%**

A detailed overview of the ingredients, their concentrations, phase allocation, and technological functions in the keratolytic wart-care cream formulation is presented in the following table.

Table 0.5: Composition, phase distribution, and functional role of ingredients in the keratolytic wart-care cream.

Phase	Ingredient	Percentage (%)	Role in formulation
Oil phase	Beeswax	6.0	Structuring agent; improves consistency and occlusive effect
Oil phase	Sweet almond oil	5.0	Emollient; improves skin softness
Oil phase	Tea tree essential oil	2.0	Fragrance and antimicrobial-supporting essential oil
Aqueous phase	Distilled water	68.7	Main aqueous vehicle
Aqueous phase	Garlic extract	5.0	Botanical active ingredient
Aqueous phase	Green tea extract	3.0	Botanical antioxidant-supporting ingredient
Active phase	Salicylic acid	5.0	Keratolytic active; promotes exfoliation of thickened skin layers
Aqueous phase	Glycerin	4.0	Humectant; reduces drying effect
Additives	Vitamin E	0.5	Antioxidant
Additives	Preservative	0.8	Microbial protection

This formulation contains a very high aqueous phase and a relatively low oil phase. This may give a light cream texture, but the stability of the system depends strongly on the emulsification method and the dispersion of salicylic acid. Since no emulsifier is listed, an emulsifying agent should be added or justified experimentally. Without an emulsifier, phase separation may occur.

Note: Due to the high aqueous content and the presence of lipophilic ingredients, the formulation requires adequate emulsification to ensure physical stability and homogeneous distribution of the active ingredients.

F/ Antiperspirant Foot Gel Formulation

This formulation is not an oil/water cream emulsion. It is a hydroalcoholic gel. A detailed overview of the ingredients, their concentrations, and their technological and cosmetic functions in the antiperspirant foot gel formulation is presented in the following table.

Table 0.6: Composition and functional role of ingredients in the antiperspirant foot gel.

Phase	Ingredient	Percentage (%)	Role in formulation
Solvent phase	Ethanol	30.15	Hydroalcoholic solvent; provides freshness and supports solubilization of some actives
Solvent phase	Distilled water	40.7	Main aqueous vehicle
Gelling phase	Carbopol®	1.0	Gelling agent; gives gel structure
Aqueous phase	Aloe vera gel	15.0	Soothing and moisturizing ingredient
Aqueous phase	Glycerin	5.0	Humectant; improves hydration
Active phase	Camphor	1.0	Refreshing sensory ingredient
Active phase	Allantoin	0.5	Soothing and skin-protecting agent
Active phase	Sage extract	1.5	Botanical deodorizing and skin-conditioning ingredient
Active phase	Clary sage extract	3.0	Botanical active and fragrance-supporting ingredient
pH/gel	Triethanolamine	0.15	Neutralizing agent; activates

adjustment			Carbopol® gel formation
Additives	Lavender essential oil	1.5	Fragrance and antimicrobial-supporting ingredient
Additives	Preservative	0.5	Microbial protection
Adjustment	Distilled water or ethanol/water q.s.	3.15	Quantity sufficient to complete 100%

The gel structure is mainly controlled by Carbopol® and triethanolamine. The ethanol/water ratio affects drying time, freshness, solubility of aromatic compounds, and skin feel. The missing 3.15% should be corrected by adding distilled water or adjusting the ethanol/water ratio according to the desired texture and evaporation rate.

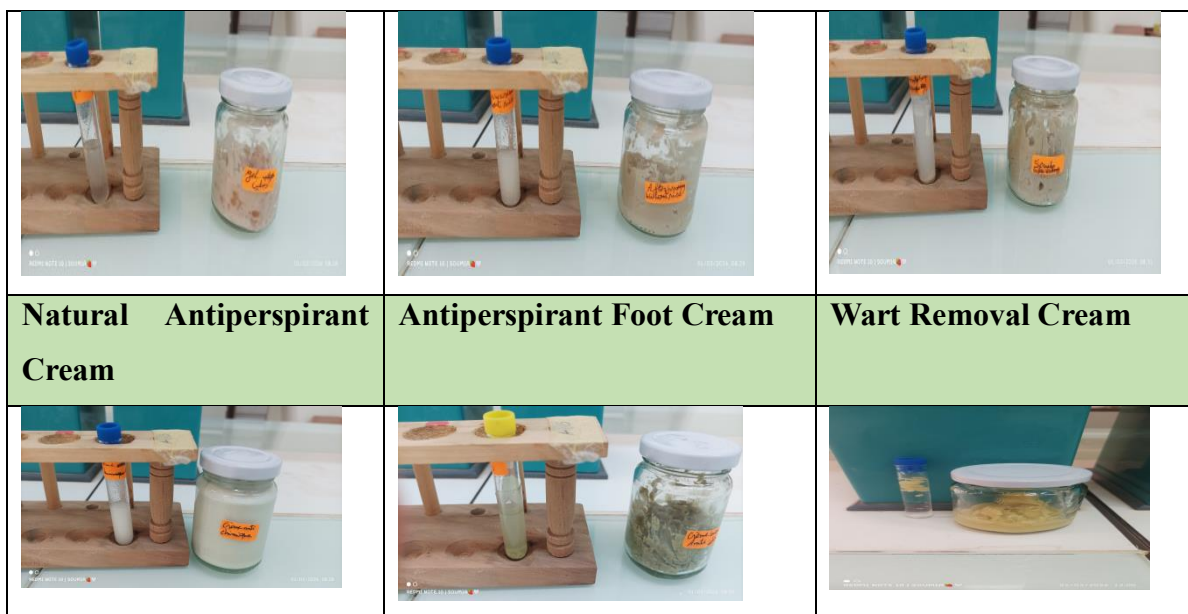
The balance between the oil and aqueous phases was established according to the intended type and texture of each formulation. For the cream formulations, an oil-in-water system was selected because it provides better spreadability, lighter skin feel, and easier incorporation of hydrophilic plant extracts. The oil phase was responsible for emollience, consistency, and skin-conditioning properties, while the aqueous phase acted as the continuous phase and allowed the incorporation of hydrophilic ingredients such as glycerin, Carbopol®, and plant extracts. Emulsifying and consistency agents, including glyceryl stearate, Lanette® O, and Cetareth, were used to stabilize the interface between the oil and aqueous phases. The final stability of each formulation depends on the phase ratio, emulsifier concentration, viscosity, particle dispersion, pH, and storage conditions.

III. 2.2. Solubility and dispersion behavior

The water solubility and dispersion characteristics of the formulated cosmetic products, which provide insight into their physicochemical behavior and potential application performance, are summarized in the following table.

Table 0.7: Solubility and dispersion test of the prepared cosmetic formulations in water.

Antiperspirant Foot Gel	Post-Depilatory Cream	Soothing	Pre-Depilatory Exfoliating Cream
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The solubility and dispersion test showed that the formulations did not behave in the same way when mixed with water. This difference is scientifically expected because the prepared products contain different proportions of aqueous ingredients, lipophilic substances, waxes, powders, clays, and emulsifiers.

The natural antiperspirant cream, the pre-depilatory exfoliating cream, and the antiperspirant foot gel showed better water dispersion. This behavior is consistent with their higher content of hydrophilic ingredients such as water, glycerin, plant extracts, Carbopol, and emulsifying agents. In these formulations, water dispersion may facilitate spreading, removal after application, and release of hydrophilic active compounds.

In contrast, the antiperspirant foot cream, the post-depilatory soothing cream, and the keratolytic wart-care formulation showed lower water solubility and remained partially aggregated or separated. This is mainly related to the presence of beeswax, shea butter, coconut oil, sweet almond oil, Cyperus oil, essential oils, and mineral powders. Such behavior does not necessarily indicate poor quality; for topical semisolid products, moderate hydrophobicity can improve adhesion to the skin and prolong contact time. However, excessive insolubility may reduce uniform distribution and should be controlled through appropriate emulsification and mixing.

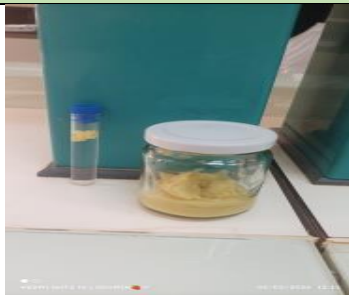
Overall, the solubility results confirm that each formulation has a physicochemical profile related to its composition. Water-dispersible systems are more appropriate for products

intended for easy spreading and rinsing, whereas more lipophilic systems are more suitable for localized or longer-contact applications.

III. 2.3. Miscibility and centrifugation stability

An overview of the miscibility characteristics and centrifugation stability of the developed cosmetic formulations, assessed through accelerated phase separation testing, is summarized in the following table.

Table 0.8: Miscibility and phase separation behavior of the prepared formulations after centrifugation.

Antiperspirant Foot Gel		Post-Depilatory Cream	Soothing Cream	Pre-Depilatory Exfoliating Cream
				
Natural Cream	Antiperspirant Cream	Antiperspirant Foot Cream		Wart Removal Cream
				

The centrifugation test is an accelerated physical stability test used to reveal early signs of creaming, sedimentation, or phase separation. The observation that several creams separated after centrifugation can be explained by their multiphase composition. Oil droplets, waxes, powders, clays, and aqueous components have different densities and polarities; therefore, they may separate under centrifugal stress even if the product remains acceptable under normal storage conditions.

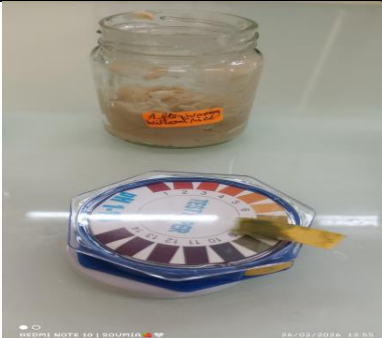
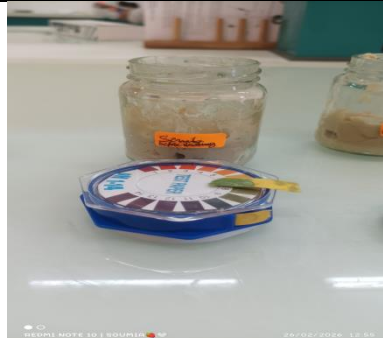
The antiperspirant foot gel remained homogeneous after centrifugation. This result is consistent with its hydroalcoholic gel structure. Carbopol, after neutralization with

triethanolamine, forms a polymeric network that immobilizes water and dissolved/dispersed ingredients. This explains the superior physical stability of the gel compared with the cream systems. For the cream formulations, phase separation after centrifugation should be interpreted carefully. It does not automatically mean that the formulation is unusable, but it indicates that the emulsion system could be improved by optimizing the emulsifier ratio, mixing speed, cooling procedure, viscosity, and particle dispersion. This is particularly important for formulations containing high levels of solid particles, such as starch, rice powder, bentonite clay, and zinc salts.

III. 2.4. pH and bromothymol blue indicator test

The acid–base characteristics of the prepared formulations were assessed using pH indicator paper and bromothymol blue indicator, and the results are summarized in the following table.

Table 0.9: pH indicator paper test of the prepared cosmetic formulations.

Natural Antiperspirant Cream		Antiperspirant Foot Cream	
			
Antiperspirant Foot Gel	Post-Depilatory Cream	Soothing Cream	Pre-Depilatory Exfoliating Cream
			

An overview of the acid–base characteristics of the developed cosmetic formulations, assessed through pH measurement and bromothymol blue indicator testing, is summarized in the following table.

Table 0.10: pH values and bromothymol blue color response of the prepared cosmetic formulations.

Formulation	Reported pH	Corrected interpretation
Chemical antiperspirant cream	6	Slightly acidic to near skin pH; acceptable for topical use.
Natural antiperspirant foot cream	6	Slightly acidic; compatible with regular skin contact.
Antiperspirant foot gel	7	Neutral; usually well tolerated but less acidic than the natural skin surface.
Pre-depilatory exfoliating cream	8	Mildly alkaline; may assist softening of the stratum corneum but should be monitored for irritation.
Post-depilatory soothing cream	9	Alkaline; may disturb the acid mantle if used frequently. Reformulation toward lower pH is recommended.
Keratolytic wart-care formulation	Not measured	pH should be measured because salicylic acid formulations require pH control for activity and tolerance.

The pH results ranged from slightly acidic to alkaline. The antiperspirant creams had pH values close to 6, which is more compatible with the acidic character of the skin surface than alkaline products. The foot gel showed a neutral pH, which may support tolerance but is not identical to the natural acidic pH of healthy skin. Literature reports that the natural skin surface is generally acidic, often below pH 5, and this acidic environment contributes to barrier function and resident flora balance.

The pre-depilatory exfoliating cream and the post-depilatory soothing cream were more alkaline. This alkalinity may be due to mineral ingredients such as bentonite clay and zinc carbonate. Although mild alkalinity may help soften the stratum corneum before exfoliation, a pH of 9 is relatively high for a leave-on post-depilatory product. Therefore, the post-

depilatory formulation should preferably be adjusted to a lower pH compatible with skin recovery, especially if it is intended for repeated use [85].

III.2.5. Long-term visual stability

The long-term observation indicated that the chemical antiperspirant cream, natural antiperspirant foot cream, antiperspirant foot gel, and keratolytic wart-care formulation remained visually stable during storage. No major change in color, odor, texture, phase separation, or visible contamination was reported. This suggests acceptable preliminary stability under the tested conditions.

The pre-depilatory exfoliating cream and post-depilatory soothing cream showed signs of deterioration. This result is scientifically plausible if the preservative was accidentally omitted, because these formulations contain water, glycerin, starch, plant extracts, and natural materials that can support microbial growth. The result demonstrates that preservation is essential in botanical cosmetic formulations, particularly when the aqueous phase and plant-extract content are high.

For a stronger thesis presentation, stability should be reported using a table including storage duration, temperature, visual appearance, odor, color, pH, texture, and phase separation. If microbiological analysis was not performed, the thesis should avoid claiming microbiological stability. An overview of the long-term visual stability of the developed cosmetic formulations, assessed through storage monitoring and observation of physical changes, is summarized in the following table.

Table 0.11: Long-term visual stability of the prepared cosmetic formulations during storage.

Antiperspirant Foot Gel	Post-Depilatory Soothing Cream	Pre-Depilatory Exfoliating Cream
		

Natural Cream	Antiperspirant	Antiperspirant Foot Cream	Wart Removal Cream
			

III.2.6. Antioxidant activity by DPPH assay

The antioxidant activity was evaluated using the DPPH radical scavenging method and expressed as ascorbic acid equivalent concentration. The calibration curve of ascorbic acid used for the quantification of antioxidant activity by the DPPH assay is presented in the following figure.

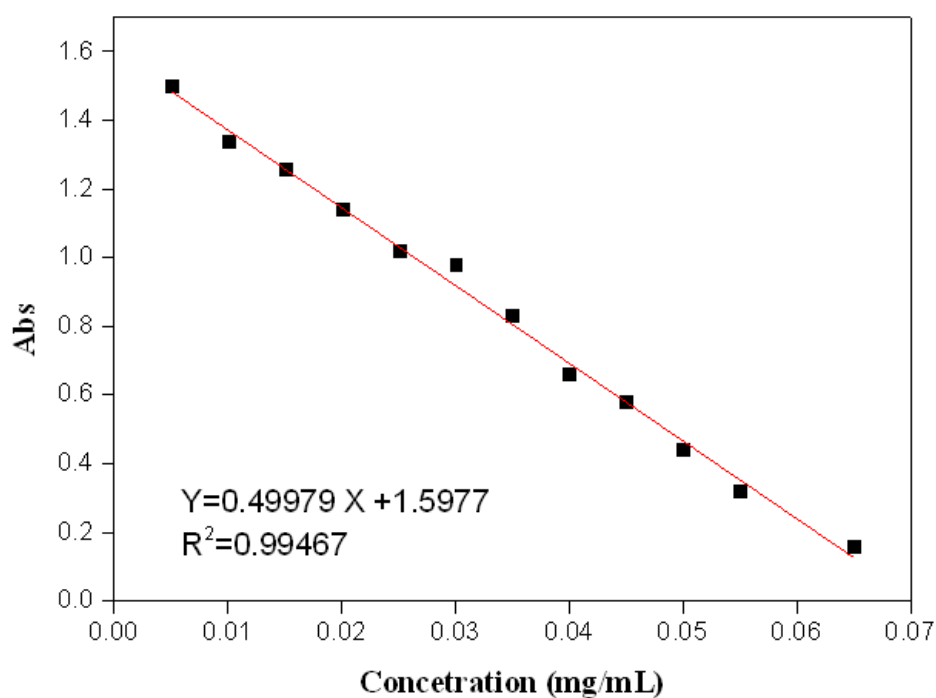


Figure 0.1: Ascorbic acid calibration curve used for antioxidant activity determination.

The ascorbic acid calibration curve showed good linearity according to the reported coefficient of determination ($R^2 = 0.99467$). This confirms that the calibration curve can be used for relative comparison between formulations, provided that the same experimental

conditions were applied to all samples. The visual color changes observed during the DPPH radical scavenging assay for the tested samples are illustrated in the following figure.

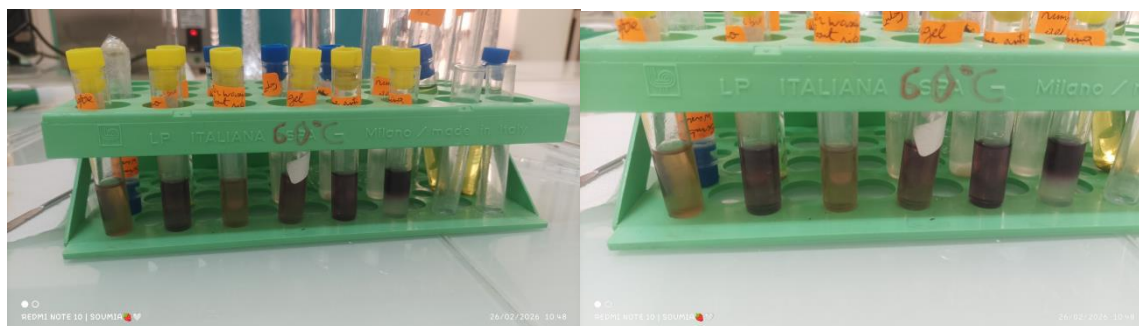


Figure 0.2: Color change observed during the DPPH antioxidant assay for the tested samples.

The antioxidant capacities of spinach chlorophyll/chlorophyllin and the prepared cosmetic formulations, expressed as ascorbic acid equivalents, are summarized in the following table.

Table 0.12: DPPH antioxidant activity of spinach chlorophyll/chlorophyllin and cosmetic formulations expressed as ascorbic acid equivalents.

Sample	Antioxidant capacity (mg ascorbic acid equivalent/mL)	Interpretation
Swiss chard chlorophyll/chlorophyllin sample	3.454	Highest antioxidant equivalent; likely associated with chlorophyll derivatives and co-extracted phenolic compounds.
Numbing gel	2.102	High antioxidant equivalent; may be due to botanical additives or antioxidant ingredients.
Pre-depilatory scrub before waxing	1.486	Moderate to high activity; compatible with green tea, chamomile, essential oils, and

		plant-based components.
Chemical antiperspirant cream	1.124	Moderate activity; probably related to sage extracts, clary sage extract, vitamin E, and lavender oil.
Natural antiperspirant foot cream	0.844	Moderate activity; expected from sage, essential oils, and lipid phase components.
Antiperspirant foot gel	0.512	Low to moderate activity; despite plant extracts, dilution in a hydroalcoholic gel may reduce measured equivalent value.
Post-depilatory cream without rice	0.384	Lowest activity among tested formulations; may reflect lower extract release or interference by clay/oil matrix.

Among the cosmetic formulations, the numbing gel and pre-depilatory scrub showed the strongest antioxidant equivalents. This may be due to the presence of plant extracts, essential oils, and antioxidant additives. The chemical antiperspirant cream and natural antiperspirant foot cream showed moderate activity, likely related to sage extract, clary sage extract, vitamin E, and essential oils. The foot gel and post-depilatory formulation showed lower activity, which may be explained by lower active concentration, extraction efficiency, matrix effects, or reduced release of antioxidant compounds into the DPPH medium.

III.3. Herbal cosmetic soaps characterisation

In this work we prepared two different soap bases on various composition for sensitive skin: olive oil-based and multi-oil herbal charcoal soaps. The appearance of the olive oil-based herbal soap and the multi-oil herbal charcoal soap prepared in this study is illustrated in the following figure.



Figure 0.3: The picture of olive oil-based and multi-oil herbal charcoal soaps.

III.3.1. Soap pH, free alkali, and foaming power

The two soap samples showed pH values of 7.5 and 7.2. These values are lower than the pH commonly reported for many conventional bathing soaps, which often fall in the alkaline range. A near-neutral pH may be advantageous for skin comfort; however, pH should be confirmed with a calibrated pH meter rather than indicator paper alone [85]. An overview of the physicochemical characteristics of the prepared herbal cosmetic soaps, including pH, free alkali content, and foaming capacity, is presented in the following table.

Table 0.13: pH, free alkali content, and foaming properties of the prepared herbal cosmetic soaps.

Soap sample	pH	Free alkali	Foam value	Corrected interpretation
Multi-oil nourishing charcoal soap	7.5	0.30%	25	Near neutral to mildly alkaline; good tolerance potential, but free alkali should be controlled for cosmetic soap.
Olive oil-based herbal charcoal soap	7.2	0.28%	28	Near neutral; slightly higher foam value in the reported test.

The measured free alkali values were 0.30% and 0.28%. These values indicate a limited residual alkali content, but for cosmetic or toilet soap, lower free caustic alkali is generally preferred to reduce irritation risk. Therefore, the thesis should not simply state that the soaps are “good”; it is better to state that the values suggest acceptable preliminary saponification

but should be compared with the applicable local or international specification for the intended product category.

The foaming test showed values of 25 and 28, with the olive oil-based herbal soap giving the higher foam value in the reported experiment. This result is possible, but it should be interpreted cautiously because foam formation depends on fatty acid profile, curing time, superfat level, hardness of water, additives such as charcoal and extracts, and shaking intensity. Coconut and castor oils are generally expected to improve foam, but a high level of additives or incomplete dissolution may reduce the measured foam height.

III.4. Chlorophyll and sodium copper chlorophyllin characterisation

III.4. 1. Characteristic of chlorophyll derivatives

Spinacia oleracea (spinach) is an appropriate plant source because its leaves contain pigments and other bioactive compounds, including phenolic compounds, which are associated with antioxidant activity. Natural chlorophyll is sensitive to light, heat, oxygen, and acidic conditions.

During chlorophyllin preparation, saponification removes the phytol chain and improves polarity. Copper complexation replaces the central magnesium ion by copper, producing copper chlorophyllin derivatives that are generally more stable than native chlorophyll. When sodium salts are formed, sodium copper chlorophyllin becomes more water soluble, which is advantageous for incorporation into aqueous or hydrogel cosmetic systems[86] .

The pigment obtained from *S. oleracea* (spinach) showed a green coloration characteristic of chlorophyll derivatives. The use of ethanol and protection from light during extraction helped limit pigment degradation. The subsequent alkaline treatment and copper complexation were intended to convert native chlorophyll into more stable copper chlorophyllin derivatives. The formation of a darker green complex after copper sulfate addition is consistent with the expected stabilization of the porphyrin structure by copper. The chlorophyll/chlorophyllin complex obtained from spinach leaves after extraction, copper complexation, and solvent evaporation is illustrated in the following figure.

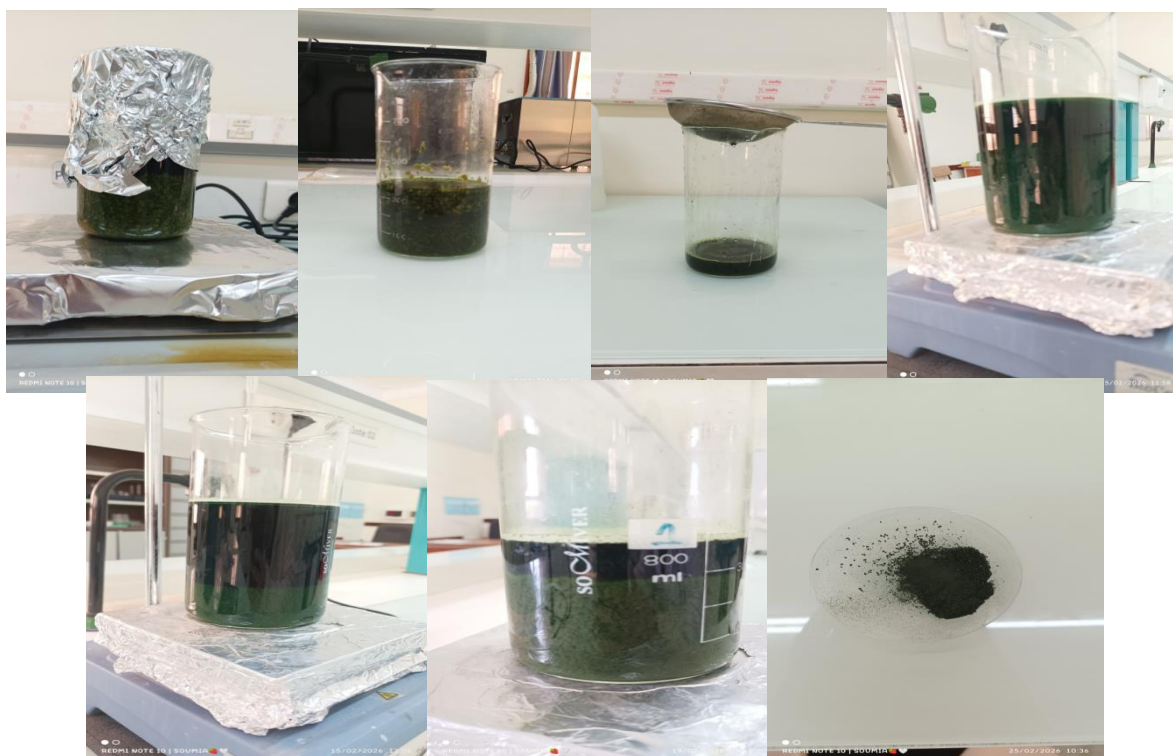


Figure 0.4: Dried spinach chlorophyll/chlorophyllin complex obtained after solvent evaporation from *S. oleracea* L. leaves.

The chlorophyll content in the plant material, and soluble Na-Cu-chlorophyllin were analysed and the result showed that the highest amount of Chl-a ($1.72 \mu\text{g}/\text{mg}$), Chl-b ($3.82 \mu\text{g}/\text{mg}$) and total chlorophyll ($5.54 \mu\text{g}/\text{mg}$) was found in soluble Na-Cu-chlorophyllin complexes (**Table 0.14**). The spectrophotometric estimation of copper showed $68.4 \mu\text{g}/\text{mL}$ of copper was present in the soluble Na-Cu-chlorophyllin complexes. A comparative analysis of chlorophyll a, chlorophyll b, total chlorophyll content, and copper concentration in raw spinach leaves and the prepared Na-Cu-chlorophyllin complexes is presented in the following table.

Table 0.15: Chlorophyll a, chlorophyll b, total chlorophyll, and copper content of spinach chlorophyll/chlorophyllin samples.

SAMPLE	Chlorophyll-a ($\mu\text{g}/\text{mg}$)	Chlorophyll-b ($\mu\text{g}/\text{mg}$)	Total chlorophyll ($\mu\text{g}/\text{mg}$)
<i>S. oleracea</i> (raw leaf)	0.61	0.45	1.06
Na-Cu-chlorophyllin complexes	1.72	3.82	5.54

III.4.2. Antioxidant activity of Na-Cu-chlorophyllin

Chlorophyll	3.454 mg eq ascorbic acid/mL
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The DPPH result showed that the *Spinacia oleracea* (spinach) chlorophyll/chlorophyllin sample had the highest antioxidant equivalent value among the tested samples. This suggests that the spinach pigment extract possesses strong radical-scavenging capacity under the experimental conditions. The antioxidant effect may be explained by the presence of chlorophyll derivatives and by phenolic compounds co-extracted from the leaves [87] .

The obtained results support the potential use of *S. oleracea* (spinach) chlorophyll/chlorophyllin as a natural pigment and antioxidant-supporting ingredient in cosmetic formulations.

III.4.3. Preparation of Alginate Beads Encapsulating Chlorophyll Derivatives

The encapsulation of chlorophyll and its derivatives (Cu-chlorophyllin and Na-Cu-chlorophyllin complexes) within alginate beads was carried out to improve their stability and functional properties. Chlorophyll is inherently unstable when exposed to light, heat, oxygen, and acidic pH, which limits its application in food, pharmaceutical, and cosmetic industries. To overcome these limitations, sodium alginate, a biocompatible and biodegradable polymer, was used as an encapsulating matrix. An overview of the alginate beads encapsulating spinach chlorophyll/chlorophyllin derivatives, prepared to enhance pigment stability and facilitate controlled release, is presented in the following figure.



Figure 0.5: Alginate beads containing spinach chlorophyll/chlorophyllin complex.

The main reasons for preparing alginate beads containing chlorophyll derivatives are as follows:

First, alginate beads provide a physical barrier that protects chlorophyll molecules from environmental factors such as light, heat, and oxygen, thereby reducing oxidative degradation. Second, encapsulation enhances the chemical stability of chlorophyll, preserving its green color and antioxidant activity over extended storage periods. Third, alginate beads allow a controlled release of the encapsulated compounds, which is particularly advantageous for pharmaceutical and nutraceutical applications. Fourth, the encapsulation process masks the undesirable taste and odor often associated with chlorophyll extracts. Finally, the conversion of liquid chlorophyll extracts into solid alginate beads facilitates handling, storage, and incorporation into various formulations.

Thus, the preparation of alginate beads encapsulating chlorophyll and its copper complexes represents a promising strategy to preserve the bioactive properties of these natural pigments while expanding their potential industrial applications [88].

General conclusion

The experimental results demonstrate that the developed cosmetic formulations presented different physicochemical behaviors depending on their composition and intended use. The water-dispersible formulations, particularly the chemical antiperspirant cream, pre-depilatory exfoliating cream, and foot gel, showed good dispersion behavior due to their higher aqueous and hydrophilic content. More lipophilic formulations, such as the antiperspirant foot cream, post-depilatory soothing cream, and keratolytic wart-care formulation, showed lower water dispersion, which may favor longer skin residence time but requires careful control of emulsion stability.

The pH results showed that the antiperspirant creams were closer to skin-compatible values, while the exfoliating and post-depilatory products were more alkaline. The post-depilatory formulation in particular should be optimized toward a lower pH if intended for frequent use. The preliminary patch test showed no visible irritation, but this result remains preliminary and should not replace standardized dermatological safety testing.

The stability results highlight the importance of preservative incorporation, especially in formulations containing water, glycerin, starch, and botanical extracts. The deterioration of some formulations was most likely associated with insufficient preservation and demonstrates the need for strict formulation control.

The antioxidant test showed that the *Spinacia oleracea* (spinach) chlorophyll/chlorophyllin sample had the highest antioxidant equivalent value, followed by the numbing gel and the pre-depilatory scrub. This confirms the potential of spinach pigment derivatives as natural antioxidant-supporting ingredients. However, further analytical confirmation is required before claiming a specific cosmetic mechanism or therapeutic effect.

Overall, the prepared formulations show promising preliminary cosmetic properties, but the thesis should present them as experimental prototypes requiring further optimization, stability testing, microbiological analysis, and standardized safety evaluation.

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Ministry of Higher Education and Scientific
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University of Ghardaïa

Faculty of Sciences and Technolog

Department of Common Teaching in
Sciences and Technology

Entrepreneurial Graduation Project
According to Ministerial Decree 1275

Project Title

SAVIÉRA BioCosmetics

Production of Plant-Based Functional Cosmetic Formulations

Prepared as a business enterprise project based on experimental work in analytical chemistry.

Degree: Master | Field: Material Sciences | Stream: Chemistry | Specialty: Analytical Chemistry

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Summary

SAVIERA BioCosmetics is a proposed micro-enterprise project for the small-scale production of plant-based functional cosmetic products. The project transforms a laboratory study on herbal cosmeceuticals into a market-oriented business concept. The proposed product line includes an underarm antiperspirant cream, antiperspirant foot cream, foot gel, pre-depilatory exfoliating cream, post-depilatory soothing cream, keratolytic wart-care cream, olive-oil herbal charcoal soap, and multi-oil nourishing charcoal soap..

The scientific basis of the project comes from the formulation and evaluation of products prepared with vegetable oils, natural waxes, plant extracts, essential oils, and mineral powders. The experimental evaluation included phase balance, organoleptic observations, solubility and dispersion behavior, miscibility and centrifugation stability, pH and bromothymol blue tests, long-term visual stability, preliminary skin tolerance, foaming behavior of soaps, free alkali content, and DPPH antioxidant activity.

The results indicate that the products have different physicochemical behaviors depending on their hydrophilic, lipophilic, mineral, and powdered composition. The foot gel showed the best homogeneity after miscibility testing because of its Carbopol-based hydroalcoholic gel structure. The antiperspirant creams showed pH values close to the skin-compatible range, while the exfoliating and post-depilatory creams showed more alkaline behavior related to their mineral-rich composition. No visible irritation was reported in the preliminary skin tolerance test. The DPPH assay indicated antioxidant potential, especially for selected botanical formulations.

The business opportunity is based on increasing consumer interest in natural, plant-based, locally produced, and scientifically supported cosmetic products. The enterprise can begin with soaps, gels, and antiperspirant creams, then expand gradually toward more advanced cosmetics-based ingredients after completing regulatory and safety requirements.

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Chapter I: Project Framework and Business Idea

I.1. Introduction to Entrepreneurship and Micro-Projects

Entrepreneurship plays an important role in transforming academic knowledge into practical economic activity. A micro-enterprise project allows students to convert laboratory results, local resources, and scientific skills into products and services with market value. In analytical chemistry, entrepreneurship is particularly relevant because product quality, stability, safety, and standardization require scientific control. Herbal cosmetic products represent a suitable field for this approach because they combine local plant resources, formulation science, quality control, and consumer demand for natural alternatives.

The proposed project is not limited to selling cosmetic products. It also aims to establish a small scientific production unit capable of developing formulations, controlling quality parameters, and improving products through continuous experimentation. This makes the project compatible with a graduation-project approach that links science, innovation, and enterprise creation.

I.2. Source of the Project Idea

The project idea comes directly from the experimental dissertation work on herbal cosmeceutical formulations. The study prepared several plant-based products using medicinal plant extracts, vegetable oils, essential oils, natural powders, and spinach chlorophyll derivatives. The obtained results showed that the formulations have measurable physicochemical and functional properties, which can be developed into prototype cosmetic products.

- Laboratory preparation of several topical formulations.
- Use of medicinal plants and natural ingredients with cosmetic relevance.
- Preliminary evaluation of pH, stability, solubility, miscibility, skin tolerance, and antioxidant activity.
- Possibility of transforming experimental prototypes into a small product line.

I.3. Importance of the Project

The project has scientific, economic, and social importance. Scientifically, it applies analytical chemistry and formulation science to the development of cosmetic products. Economically, it proposes a small enterprise that can valorize accessible raw materials such as vegetable oils, medicinal plants, essential oils, and natural powders. Socially, it responds to consumer interest in natural and locally produced personal-care products.

- Valorization of medicinal plants and natural bioactive compounds.
- Development of local cosmetic prototypes using accessible materials.
- Creation of student entrepreneurship opportunities.
- Potential contribution to local employment and small-scale manufacturing.
- Promotion of quality control and scientific validation in herbal cosmetics.

I.4. Project Identification

I.4.1 Project Name

SAVIÉRA Cosmetics

SAVIÉRA Cosmetics is a micro-enterprise specialized in the development, production, and marketing of natural cosmetic products formulated with scientifically studied plant extracts, with a strong emphasis on quality, efficacy, and safety.



I.4.2 Project Location and Reasons for Selection

The project is proposed to be established in the province of Ghardaïa, within a suitable business or industrial zone that allows for the manufacturing of cosmetic products and the storage of raw materials and finished goods.

The location was selected for the following reasons:

- Availability of industrial premises and workshops at lower costs compared to major cities.
- Easy access to the local market and the markets of southern Algeria.
- Potential for future expansion of the business.
- Contribution to the diversification of local economic activities and job creation.
- Proximity to local suppliers of certain natural and plant-based materials.

I.4.3 Product Description and Competitive Advantages

The project aims to produce a range of natural cosmetic products, including:

- Moisturizing and skincare creams.
- Plant-based serums.

- Natural soaps.
- Hair care products.
- Cosmetic products formulated with plant and herbal extracts.

I.4.4 Product Advantages

- Use of carefully selected natural ingredients.
- Product development based on scientific research findings and academic studies.
- Quality control through stability testing, pH evaluation, and antioxidant activity assessment.
- Formulations free from certain harsh chemicals commonly found in conventional products.
- Suitability for different skin types.
- Professional packaging and product presentation that enhance consumer confidence.
- Provision of a high-quality local alternative to imported products.

Table 0.1: *Project identification card.*

Element	Description
Project name	SAVIÉRA BioCosmetics
Business activity	Production and commercialization of plant-based cosmetic creams, gels, soaps
Scientific basis	Experimental preparation and characterization of herbal cosmetic formulations
Proposed location	Ghardaïa, Algeria
Target market	Consumers looking for natural skin-care, foot-care, depilatory-care, and herbal soap products
Initial scale	Small-Scale cosmetic manufacturing factory (mini factory)
Future development	Individual consumers, pharmacies, parapharmacies, beauty salons, cosmetic retailers, online customers, and wholesale distributors seeking high-quality natural cosmetic products.

I.5. Description of the Products



Antiperspirant Foot Gel		Post-Depilatory Cream	Soothing	Pre-Depilatory Exfoliating Cream
				
Natural Cream	Antiperspirant	Antiperspirant Foot Cream		Wart Removal Cream
				

Figure I.2: Visual appearance of the prepared cosmetic formulations.



Figure I.3: The picture of olive oil-based and multi-oil herbal charcoal soaps.

Table 0.4: Proposed product portfolio based on the experimental work.

Product	Product Type	Cosmetic Purpose	Main Functional Ingredients	Launch Year	Target Market	Justification
Under Glow	Antiperspirant & Brightening Cream	Underarm perspiration control, deodorizing and skin brightening	Zinc oxide, sage extract, clary sage extract, glycerin, shea butter	2026	B2C & B2B	Flagship product with strong consumer demand and high market potential in pharmacies, beauty salons and retail stores.
HairLess	Post-Depilatory Hair Reduction Cream	Hair growth reduction and skin soothing after depilation	Cyperus Rotundus Oil, Shea Butter, Chamomile Extract, Allantoin	2026	B2C & B2B	Complements Under Glow and targets a large female skincare segment.
Therapeutic Charcoal Soap	Natural Therapeutic Soap	Deep cleansing, oil control and skin purification	Activated Charcoal, Olive Oil, Coconut Oil, Castor Oil, Kaolin Clay	2026	B2C & B2B	Low production cost, high demand and suitable for both retail and wholesale distribution.
Antiperspirant Foot Cream	Foot Care Cream	Foot perspiration and odor control	Zinc Oxide, Sage Extract, Shea Butter	2028	B2C & B2B	Uses existing production infrastructure and expands

						the personal care product line.
Antiperspirant Foot Gel	Hydroalcoholic Gel	Foot refreshing and odor control	Aloe Vera, Carbopol, Sage Extract, Camphor, Glycerin	2028	B2C & B2B	Expands the foot-care range and increases product diversity.
Pre-Depilatory Exfoliating Cream	Cream/Scrub	Skin preparation before hair removal	Rice Powder, Bentonite Clay, Green Tea Extract, Allantoin	2029	B2C & B2B	Creates a complete depilation care system and increases product portfolio depth.
Post-Depilatory Soothing Cream	Cream	Skin soothing after hair removal	Chamomile Extract, Green Tea Extract, Shea Butter, Allantoin	2029	B2C & B2B	Strengthens the HairLess product family and improves customer retention.
Natural Active Ingredients Line	Cosmetic Ingredients	Supply of cosmetic actives and botanical ingredients	Plant Extracts, Botanical Oils.	2030	B2B	Diversifies revenue streams and positions SAVIÉRA BioCosmetics as a supplier to cosmetic manufacturers.

I.6. Distinctive Features Compared with Similar Products

- Plant-based positioning: the formulations incorporate medicinal plant extracts, essential oils, vegetable oils, and natural powders.
- Scientific basis: the products are supported by laboratory characterization such as pH, stability, solubility, miscibility, and antioxidant tests.
- Local adaptability: the products can be adapted to local consumer needs such as hot climate, foot perspiration, and skin-care habits.
- Product diversity: the project combines creams, gels, and soaps.
- Progressive development: the enterprise can begin with simple products such as soaps and gels, then move toward more advanced formulations after additional safety tests.

I.7. Production Process

1. Selection and quality inspection of raw materials.
2. Weighing of ingredients according to the approved formulation.
3. Mixing of ingredients and preparation of the cosmetic product.
4. Quality control and performance of the required tests.
5. Filling of the product into suitable containers.
6. Labelling and final packaging.
7. Storage of finished products.
8. Distribution and marketing.

The production process will be organized according to the type of product. Creams require oil-phase preparation, aqueous-phase preparation, heating, emulsification, cooling, addition of heat-sensitive ingredients, packaging, and quality control. Gels require dispersion of Carbopol in the hydroalcoholic phase, neutralization, incorporation of actives, homogenization, and packaging. Soaps require calculation of the alkaline solution, saponification, molding, hardening, curing, and quality control.

Table 0.5: *Production stages for each product group.*

Product group	Main production steps
Creams	Weigh ingredients; prepare oil phase; prepare aqueous phase; heat phases; emulsify; cool; add extracts/essential oils/preservative; homogenize; package; test pH and stability
Gels	Prepare water/ethanol phase; disperse Carbopol; add glycerin and Aloe vera; neutralize with triethanolamine; add actives and fragrance; package; test homogeneity and pH
Soaps	Calculate NaOH; prepare alkaline solution; mix with oils; reach trace; add charcoal/extracts/fragrance; mold; harden; cure; test pH, free alkali, and foam

I.8. Required Equipment and Materials

Table 0.6: *Main equipment and operational materials.*

Category	Required elements
Production	Industrial cosmetic homogenizer, Mixing and preparation tanks, Stainless-steel vessels, hot plates, magnetic stirrers, overhead mixer, homogenizer, molds, soap cutting tools, Stainless steel worktables
Measurement and quality control	Laboratory equipment for analyses and testing, Analytical balance, pH meter, thermometer, viscometer if available, Laboratory Oven, Glassware Set, Laboratory Refrigerator, Microscope, centrifuge, UV-Visible spectrophotometer or outsourced analysis
Packaging	Jars, bottles, soap boxes, labels, sealing tools, Semi-automatic filling machine, batch coding tools, Labelling machine, Air Compressor, Container sealing machine.
Storage	Storage shelves and warehouse facilities, cool storage cabinet, raw-material containers, finished-product area
Equipment	Desktop Computers, Multifunction Printer (Print/Scan/Copy) and Office Furniture Set (Desks, Chairs and Cabinets)
Safety and hygiene	Gloves, masks, laboratory coats, disinfectants, Cleaning and sterilization equipment, fire extinguisher, ventilation

I.9. Human Resources

Table 0.7: Proposed human resources.

Position	Number	Main Responsibilities
General Manager	1	Overall management of the company, strategic planning, decision-making, supervision of operations, supplier and partner relations.
Production Manager	1	Planning and supervising production activities, scheduling manufacturing operations, monitoring productivity and ensuring compliance with procedures.
Quality control manager	1	Conducting quality inspections, monitoring product quality, performing laboratory tests, ensuring compliance with cosmetic standards and specifications.
Accountant	1	Financial management, bookkeeping, payroll preparation, tax records, budgeting and financial reporting.
Marketing and sales officer	1	Marketing strategy implementation, social media management, customer acquisition, distributor relations and sales development.
Production worker	2	Raw material preparation, mixing operations, manufacturing support, equipment cleaning and production assistance.
Packaging worker	1	Filling, labelling, packaging, product inspection, storage preparation and shipment preparation.

I.10. The Five Key Questions

Table 0.8: Five-question analysis of the project idea.

Question	Answer
What?	SAVIÈRA BioCosmetics is a mini cosmetic manufacturing factory specializing in the development, production, packaging, and commercialization of natural cosmetic products. The company will initially launch three flagship products: Under Glow, HairLess, and Therapeutic Charcoal Soap. The project combines scientific formulation, quality control, and industrial manufacturing to provide innovative cosmetic solutions for the Algerian market.
Who?	The project was developed to respond to the growing demand for effective, safe, and affordable cosmetic products in Algeria. Consumers are increasingly seeking natural and scientifically formulated cosmetics while local manufacturers have the opportunity

	to reduce dependence on imported products. Furthermore, the project contributes to job creation, local industrial development, and economic diversification.
Why?	The project targets both Business-to-Consumer (B2C) and Business-to-Business (B2B) markets. B2C Customers • Women aged 18–45 years. • Men interested in personal care products. • Students and young professionals. • Consumers seeking natural skincare solutions. B2B Customers • Pharmacies. • Parapharmacies. • Beauty salons. • Cosmetic retailers. • Wholesalers and distributors. • Private-label cosmetic brands. • Cosmetic manufacturers.
Where?	The factory will be established in Algeria within a suitable industrial or commercial area offering access to transportation networks, suppliers, utilities, and distribution channels. The company's products will be distributed nationwide through pharmacies, cosmetic stores, beauty salons, distributors, and online sales platforms.
When?	The project will be implemented through a phased growth strategy to ensure sustainable development and efficient resource utilization. Phase 1 (2026–2027) • Under Glow

- HairLess
- Therapeutic Charcoal Soap

Phase 2 (2028)

- Antiperspirant Foot Cream
- Antiperspirant Foot Gel

Phase 3 (2029)

- Pre-Depilatory Exfoliating Cream
- Post-Depilatory Soothing Cream

Phase 4 (2030)

- Natural Active Ingredients Line

This phased implementation plan allows SAVIÉRA BioCosmetics to establish a strong market presence, diversify its product portfolio, and gradually expand into industrial B2B activities while maintaining operational and financial stability.

I.11. Business Model Canvas (BMC)

Table 0.9: Business Model Canvas (BMC).

Key Partners	Key Activities	Value Propositions
Raw material suppliers, Packaging suppliers, Microbiological Lab, Quality analysis laboratory, CDE/NESDA support structures.	Product formulation and development, Cosmetic manufacturing, Quality control and laboratory testing, Packaging and labelling, Marketing and promotion, Distribution and logistics, Customer relationship	High-quality natural cosmetic products, Scientifically formulated products, Locally manufactured in Algeria, Competitive prices compared to imported brands, Safe and effective formulations, Progressive product

	management, Product innovation and R&D.	diversification, Reliable quality assurance system.
Key Resources Mini cosmetic factory, Brand identity, Analytical chemists, Production equipment, Marketing team, Management, Quality control laboratory, Skilled workforce, Product formulations, Working capital, Supplier network, Distribution network.	Customer Relationships Direct advice; social-media communication; product-use instructions; after-sales follow-up; loyalty program; sampling at events, Customer support, Promotions and discounts, Professional customer support.	Customer Segments - B2C Customers:(Women (18–45 years), Men interested in personal care, Students and young professionals, Consumers seeking natural cosmetics). - B2B Customers:(Pharmacies, Parapharmacies, Beauty salons, Cosmetic stores, Wholesalers and distributors, Private-label brands, Cosmetic manufacturers).
Channels Pharmacies, Parapharmacies, Beauty salons, Cosmetic retailers, Distributors and wholesalers, Company website, Facebook, Instagram, TikTok, E-commerce platforms, Trade fairs and exhibitions, University exhibitions.	Cost Structure Raw materials, Packaging materials, Salaries and wages, Utilities (water, electricity, gas), Rent and maintenance, Marketing and advertising, Transportation and logistics, Quality control expenses, Administrative expenses, Equipment depreciation.	Revenue Streams Retail product sales (B2C), Wholesale product sales (B2B), Pharmacy sales, Distributor partnerships, Beauty salon sales, Private-label manufacturing (future), OEM manufacturing services (future), Cosmetic ingredient sales (future), Natural active ingredient supply (future), Future chlorophyllin ingredient/bead sales.

a. Key Partners

Key Partners are the organizations and entities that support the company's operations and contribute to its success.

For SAVIÉRA BioCosmetics, key partners include raw material suppliers, packaging suppliers, equipment suppliers, logistics providers, and regulatory authorities. These partners ensure a stable supply chain, facilitate market access, and support business growth.

b. Key Activities

Key Activities represent the most important actions the company must perform to create value and generate revenue.

The main activities of SAVIÉRA BioCosmetics include cosmetic product formulation, manufacturing, quality control, packaging, labeling, marketing, distribution, and continuous product development. These activities ensure that customers receive safe and effective cosmetic products.

c. Value Propositions

The Value Proposition explains why customers should choose the company's products instead of competitors' offerings.

SAVIÉRA BioCosmetics offers high-quality natural cosmetic products developed through scientific formulations and manufactured locally in Algeria. The company provides effective, affordable, and safe products while maintaining strict quality standards and attractive packaging.

d. Customer Relationships

Customer Relationships describe how the company interacts with its customers and maintains customer loyalty.

The company builds relationships through customer support, social media engagement, educational content, promotional campaigns, loyalty programs, and professional communication with pharmacies, distributors, and beauty salons.

e. Customer Segments

Customer Segments represent the groups of customers targeted by the company.

SAVIÉRA BioCosmetics serves both B2C and B2B customers. B2C customers include consumers seeking personal care and skincare products. B2B customers include pharmacies, parapharmacies, beauty salons, cosmetic retailers, distributors, wholesalers, and private-label brands.

f. Key Resources

Key Resources are the assets required to operate the business successfully.

The main resources include the mini cosmetic factory, production equipment, quality control laboratory, skilled workforce, cosmetic formulations, the SAVIÉRA brand, financial capital, and the supplier and distribution network.

g. Channels

Channels represent the methods used to deliver products and communicate with customers.

SAVIÉRA BioCosmetics distributes its products through pharmacies, beauty salons, cosmetic retailers, distributors, wholesalers, social media platforms, e-commerce channels, and industry exhibitions.

h. Cost Structure

The Cost Structure identifies the major expenses required to operate the business.

The primary costs include raw materials, packaging materials, employee salaries, utilities, rent, transportation, marketing expenses, quality control costs, administrative expenses, equipment maintenance, and depreciation.

i. Revenue Streams

Revenue Streams describe how the company generates income.

SAVIÉRA BioCosmetics generates revenue through retail sales (B2C), wholesale sales (B2B), pharmacy sales, distributor partnerships, beauty salon sales, and future activities such as private-label manufacturing, OEM services, and cosmetic ingredient supply.

I.12. SWOT Analysis of SAVIÉRA Cosmetics

Table 0.10: *SWOT analysis.*

Strengths	Weaknesses
Strong product differentiation through specialized cosmetic products (Under Glow, HairLess, and Therapeutic Charcoal Soap).	New brand with limited market recognition during the launch phase.

Scientific formulation and quality control approach.	Limited operating experience compared to established competitors.
Local manufacturing reduces dependence on imported products.	High initial investment requirements.
Hybrid business model (B2B and B2C).	Dependence on some imported raw materials.
Product diversification and long-term expansion strategy.	Limited distribution network at the beginning.
Dedicated quality control laboratory.	Marketing budget constraints during the early stages.
Opportunities	Threats
Growing demand for natural and functional cosmetic products.	Strong competition from international cosmetic brands.
Increasing consumer preference for locally manufactured products.	Entry of new competitors into the market.
Expansion of e-commerce and digital marketing channels.	Fluctuation in raw material prices.
Growth of pharmacies, beauty salons, and cosmetic retailers.	Changes in cosmetic regulations and standards.
Future expansion into private-label manufacturing and OEM services.	Economic instability affecting consumer purchasing power.
Development of cosmetic ingredient supply activities (B2B).	Supply chain disruptions and import restrictions.

Chapter II: Market Study and Marketing Strategy

II.1. Target Market and Customers

The target market includes consumers who are interested in natural cosmetics, daily hygiene, foot care, depilatory care, and herbal soaps. The products can be sold individually or as specialized care kits. Because the project is at the micro-enterprise stage, the first target should be local and regional markets before national distribution.

Table 0.1: Target customer segments.

Segment	Category	Main Needs
Women (18–45 years)	B2C	Brightening, hair reduction, skincare
Men (18–45 years)	B2C	Cleansing, grooming, personal care
Students and Young Adults	B2C	Affordable and effective cosmetics
Working Professionals	B2C	Practical daily-care products
Pharmacies and Parapharmacies	B2B	Reliable cosmetic products for resale
Beauty Salons and Spas	B2B	Professional cosmetic solutions
Cosmetic Retailers	B2B	Diverse product portfolio
Wholesalers and Distributors	B2B	Bulk purchasing and distribution
Private-Label Brands	B2B	Manufacturing partnerships
Cosmetic Manufacturers	B2B	Cosmetic ingredients and active compounds

II.2. Why and When Customers Buy

Table 0.2: Customer buying behavior.

Segment	Main Purchase Drivers
Women (18–45 years)	Product effectiveness, safety, price, and recommendations
Men (18–45 years)	Product quality, convenience, and personal care needs
Students and Young Adults	Affordability, trends, and social media influence
Working Professionals	Quality, practicality, and brand reliability
Pharmacies and Parapharmacies	Product demand, profitability, and supplier reliability
Beauty Salons and Spas	Product performance and customer satisfaction
Cosmetic Retailers	Product variety, margins, and market demand
Wholesalers and Distributors	Competitive pricing, volume sales, and supplier consistency

II.3. Competitor Analysis

The project will face both direct and indirect competitors. Direct competitors include local and imported natural cosmetic brands, soap producers, and herbal product shops. Indirect competitors include conventional cosmetic brands, antiperspirants, depilatory-care products, and pharmaceutical skin-care products. SAVIERA must compete through product transparency, local identity, quality control, attractive packaging, and customer education.

Table 0.3: *Competitor analysis.*

Competitor type		Strengths	Weaknesses
Imported cosmetic brands	Nivea, Dove, Garnier, L'Oréal Paris, Neutrogena	Strong international reputation; high product quality; extensive product range; advanced R&D; powerful marketing campaigns; wide distribution network	Higher prices; dependence on imports; limited use of local natural ingredients; less adaptation to local consumer preferences
Local Manufacturers	Venus Algeria, Biopharm Cosmetics, local cosmetic companies	Competitive prices; good knowledge of the Algerian market; faster distribution; easier customer access; compliance with local regulations	Smaller R&D budgets; lower international recognition; limited product innovation compared to global brands
Artisanal Producers	Handmade soap makers, small herbal cosmetic workshops, local natural skincare producers	Use of natural ingredients; authentic handmade image; flexible production; personalized products	Small production capacity; inconsistent product quality; limited quality control; weak branding and distribution
Online sellers	Instagram stores, Facebook cosmetic pages, online beauty shops, e-commerce retailers	Low operating costs; direct communication with customers; rapid marketing through social	Limited customer trust; intense price competition; inconsistent product authenticity; limited

		media; broad geographic reach	after-sales service; dependence on digital platforms
SAVIÉRA BioCosmetics	Under Glow, HairLess, Therapeutic Charcoal Soap	Scientific formulations, quality control laboratory, local manufacturing, B2B and B2C model, progressive product diversification	New market entrant with limited brand awareness

II.4. Marketing Mix: 5Ps

Table 0.4: 5Ps marketing strategy.

Element	Strategy
Product	High-quality natural cosmetic products with scientifically formulated ingredients and attractive packaging. Initial products include Under Glow, HairLess, and Therapeutic Charcoal Soap, followed by gradual product diversification.
Price	Competitive and value-based pricing strategy with special discounts for wholesalers, pharmacies, and distributors.
Place	Distribution through pharmacies, parapharmacies, beauty salons, cosmetic retailers, distributors, social media, e-commerce platforms, and exhibitions.
Promotion	Digital marketing, social media campaigns, influencer partnerships, promotional offers, sampling campaigns, exhibitions, and customer loyalty programs.
People	Qualified management team, production staff, quality control personnel, sales and marketing staff, distributors, and business partners.

II.5. Brand Positioning

SAVIÉRA BioCosmetics is positioned as a high-quality Algerian cosmetic brand that combines natural ingredients with scientific formulation to provide safe, effective, and affordable personal care solutions. The company differentiates itself through local manufacturing, strict quality control, innovative product development, and a hybrid B2B and B2C business model. By offering products that balance quality, effectiveness, and accessibility, SAVIÉRA BioCosmetics aims to establish a strong reputation among consumers, pharmacies, beauty salons, and distributors while competing with both imported and local cosmetic brands.

II.6. Risk Assessment

Table 0.5: Risk evaluation and mitigation plan.

Risk	Probability	Impact	Mitigation measures
Low sales during the launch phase	Medium	High	Implement intensive marketing campaigns, promotional offers, and strengthen distribution channels.
Strong market competition	High	Medium	Differentiate products through quality, innovation, natural ingredients, and competitive pricing.
Raw material price fluctuations	Medium	High	Establish relationships with multiple suppliers and maintain safety stock levels.
Supply chain disruptions	Medium	High	Diversify suppliers and maintain strategic inventories of critical materials.
Product quality issues	Low	High	Apply strict quality control procedures and regular laboratory testing.
Regulatory changes	Medium	Medium	Continuously monitor cosmetic regulations and ensure compliance with legal requirements.
Cash flow shortages	Medium	High	Maintain adequate working capital and closely monitor financial performance.
Equipment breakdowns	Medium	Medium	Implement preventive maintenance programs and maintain spare parts inventory.
Negative customer feedback	Medium	Medium	Establish effective customer service and quickly address complaints and product issues.
Economic instability and reduced purchasing power	Medium	Medium	Offer products at different price levels and continuously optimize production costs.

Chapter III: Sales, Costs, Capital, and Financing

The following financial plan is a preliminary academic scenario for the first year of activity. It is not a final investment plan. The values must be updated using real supplier quotations, confirmed rent, confirmed salary levels, tax advice, and official regulatory costs.

III.1. Product Price and Variable Cost Assumptions

Table 0.1: Preliminary pricing and variable-cost assumptions.

Product	Unit	Selling price (DZD)	Variable cost/unit (DZD)	Contribution margin/unit (DZD)
Under Glow	50 g jar	1500	450	1050
HairLess	50 g jar	1700	500	1200
Therapeutic Charcoal Soap	100 g Bar	700	220	480
Antiperspirant Foot Cream	50 g jar	1200	400	800
Antiperspirant Foot Gel	75 ml Bottle	1000	350	650
Pre-Depilatory Exfoliating Cream	100 g jar	1300	450	850
Post-Depilatory Soothing Cream	100 g jar	1400	500	900

III.2. Monthly Sales Plan for the First Year

Table 0.2: Monthly sales plan and operating margin estimate.

Month	Units	Revenue (DZD)	Variable cost (DZD)	Gross margin (DZD)	Fixed costs (DZD)	Estimated operating result (DZD)
Month 1	2,000	2,000,000	700,000	1,300,000	750,000	550,000
Month 2	2,200	2,200,000	770,000	1,430,000	1,500,000	680,000
Month 3	2,400	2,400,000	840,000	1,560,000	1,500,000	810,000
Month 4	2,600	2,600,000	910,000	1,690,000	1,500,000	940,000
Month 5	2,800	2,800,000	980,000	1,820,000	1,500,000	1,070,000

Month 6	3,000	3,000,000	1,050,000	1,950,000	1,500,000	1,200,000
Month 7	3,100	3,100,000	1,085,000	2,015,000	1,500,000	1,265,000
Month 8	3,200	3,200,000	1,120,000	2,080,000	1,500,000	1,330,000
Month 9	3,300	3,300,000	1,155,000	2,145,000	1,500,000	1,395,000
Month 10	3,400	3,400,000	1,190,000	2,210,000	1,500,000	1,460,000
Month 11	3,500	3,500,000	1,225,000	2,275,000	1,500,000	1,525,000
Month 12	3,600	3,604,000	1,261,400	2,342,600	1,500,000	1,592,600
Annual total	35,100	35,104,000	12,286,400	22,817,600	9,000,000	13,817,600

The monthly plan assumes progressive market penetration during the first year. Sales are expected to increase gradually as customer trust, distribution channels, and brand visibility improve.

III.3. Direct and Indirect Costs

Table 0.3: Cost classification.

Cost category	Examples
Direct variable costs	Raw materials, plant extracts, vegetable oils, shea butter, activated charcoal, potassium alum, zinc oxide, essential oils, preservatives, packaging materials, labels, cartons, and direct production labor.
Fixed monthly costs	Factory rent, employee salaries, utilities (water, electricity, gas), internet and telephone services, cleaning supplies, maintenance, transportation, marketing expenses, accounting services, and security services.
Quality and compliance costs	Microbiological testing, pH testing, stability testing, laboratory reagents, safety assessments, product registration, labeling verification, and outsourced laboratory services.
Distribution and Marketing Costs	Product delivery, distributor support, advertising campaigns, social media marketing, exhibitions, promotional materials, and product sampling.
Administrative Costs	Office supplies, printing, archiving, software subscriptions, banking charges, and communication expenses.
Depreciation Costs	Gradual cost allocation of production and laboratory equipment such as mixing tanks, homogenizer, filling machine, labeling machine, balances, pH meter, viscometer, microscope, oven, and office equipment.

Financial Costs	Bank fees, financing charges, loan interest (if applicable), and transaction costs.
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Table 0.4: *Estimated fixed monthly costs.*

Fixed cost item	Monthly estimate (DZD)
Rent	60 000 DZD
Salaries and social charges	500 000 DZD
Electricity, water, internet	30 000 DZD
Marketing and communication	50 000 DZD
Transport and delivery	30 000 DZD
Cleaning, maintenance, consumables	20 000 DZD
Accounting and administrative costs	20 000 DZD
Insurance and Miscellaneous Expenses	20 000 DZD
Total Estimated Fixed Costs	730 000 DZD

III.4. Estimated Investment Capital

Table 0.5: *Estimated capital requirement.*

Investment item	Estimated amount (DZD)
Formulation and production equipment	4 500 000 DZD
Laboratory Equipment	2 000 000 DZD
Packaging Equipment and Tools	1 500 000 DZD
Office and Administrative Equipment	500 000 DZD
Factory Furniture, Shelving and Storage Systems	700 000 DZD
Initial Raw Materials Stock	3 500 000 DZD
Initial Packaging Materials Stock	1 000 000 DZD
Registration, Legal and Administrative Expenses	300 000 DZD
Factory Preparation and Installation Costs	3 000 000 DZD
Working capital reserve	5 000 000 DZD

Estimated total capital requirement: 22 000 000 DZD.

III.5. Financing Sources

Table 0.6: Possible financing structure.

Source	Estimated role	Comment
Personal contribution	10-20% of total capital	Shows founder commitment and reduces dependence on debt
Family contribution	Optional	Can cover part of working capital or packaging costs
NESDA or support agency	To be verified officially	Possible support, training, and financing mechanisms for micro-enterprises
Bank loan	Possible if required	Requires repayment plan and guarantees
Reinvestment of profits	From months 6-12	Supports gradual expansion without excessive debt

III.6. Depreciation of Fixed Assets

Table 0.7: Depreciation estimate.

Asset group	Value (DZD)	Useful life (years)	Annual depreciation (DZD)
Production equipment	5 000 000 DZD	5	1 000 000 DZD
Laboratory equipment	2 500 000 DZD	5	500 000 DZD
Packaging tools	1 500 000 DZD	4	375 000 DZD
Furniture and storage	700 000 DZD	5	140 000 DZD
Office and Administrative Equipment	500 000 DZD	3	166 667 DZD
Factory Preparation and Installation Costs	3 000 000 DZD	10	300 000 DZD

Estimated annual depreciation: 13 200 000 DZD.

Chapter IV: Financial Analysis and Feasibility Evaluation

IV.1. Estimated Profit and Loss Statement

Table 0.1: Estimated profit and loss statement for year 1.

Item	Annual estimate
Total sales revenue	31 104 000 DZD
Variable production costs	10 886 400 DZD
Gross margin	20 217 600 DZD
Fixed operating costs	9 000 000 DZD
Depreciation	2 481 667 DZD
Estimated profit before tax	8 735 933 DZD

The estimated profit before tax is positive under the assumptions used. However, the result is sensitive to real market demand, raw-material prices, production losses, tax treatment, and regulatory costs.

IV.2. Cash Flow Plan

Table 0.2: Simplified monthly cash-flow plan.

Month	Opening cash (DZD)	Revenue (DZD)	Variable cost (DZD)	Fixed costs (DZD)	Estimated operating result (DZD)	Closing cash (DZD)
Month 1	7,700,000	2,000,000	700,000	750,000	550,000	8,250,000
Month 2	8,250,000	2,200,000	770,000	750,000	680,000	8,930,000
Month 3	8,930,000	2,400,000	840,000	750,000	810,000	9,740,000
Month 4	9,740,000	2,600,000	910,000	750,000	940,000	10,680,000
Month 5	10,680,000	2,800,000	980,000	750,000	1,070,000	11,750,000
Month 6	11,750,000	3,000,000	1,050,000	750,000	1,200,000	12,950,000
Month 7	12,950,000	3,100,000	1,085,000	750,000	1,265,000	14,215,000
Month 8	14,215,000	3,200,000	1,120,000	750,000	1,330,000	15,545,000
Month 9	15,545,000	3,300,000	1,155,000	750,000	1,395,000	16,940,000
Month 10	16,940,000	3,400,000	1,190,000	750,000	1,460,000	18,400,000
Month 11	18,400,000	3,500,000	1,225,000	750,000	1,525,000	19,925,000
Month 12	19,925,000	3,604,000	1,261,400	750,000	1,592,600	1,592,600

The simplified cash-flow plan shows the importance of maintaining working capital during the first months. If sales grow more slowly than expected, the enterprise must reduce production volume, delay equipment purchases, or increase promotional efforts.

IV.3. Break-Even Point

Table 0.3: Break-even analysis.

Indicator	Value
Weighted average contribution margin per unit	850 DZD/unit
Estimated monthly fixed costs	750 000 DZD
Break-even quantity	882 units/month
Break-even revenue	1 100 000 DZD

Under the assumed product mix and prices, the project must sell approximately the break-even quantity each month to cover fixed costs. The soap and gel products can help reach this volume because they are easier to produce and can be sold frequently.

IV.4. Sensitivity Analysis

Table 0.4: Sensitivity analysis.

Scenario	Estimated profit before tax
Base case	13 790 333 DZD
Sales decrease by 10%	9 902 333 DZD
Variable costs increase by 10%	12 429 533 DZD
Sales decrease by 10% and variable costs increase by 10%	8 541 533 DZD

The sensitivity analysis shows that the project remains dependent on sales volume and raw-material costs. To reduce risk, the enterprise should begin with a limited product range, control inventory, and use customer feedback before scaling up production.

IV.5. Payback Period

Table 0.5: Payback-period estimate.

Indicator	Value
Estimated total investment	25 000 000 DZD

Estimated annual profit before tax	8 735 933 DZD
Estimated payback period	2.86 years

This payback estimate is optimistic because it does not include all possible taxes, loan interest, product returns, regulatory testing costs, or unexpected losses. A more conservative plan should be prepared using confirmed quotations and real sales data after pilot marketing.

Chapter V: Legal and Procedural Aspects

V.1. Proposed Legal Form

For the academic project, an EURL or SARL structure may be considered depending on the number of founders. If one founder creates the enterprise, an EURL can be suitable because it separates the business activity from personal assets within a formal legal structure. If several students create the business together, an SARL may be more appropriate. The final decision must be taken with legal and accounting advice.

Table 0.1: Possible legal forms.

Legal form	When suitable	Comment
EURL	One founder	Recommended if the project is owned by a single entrepreneur. Provides limited liability and a professional legal structure.
SARL	Two or more partners	Recommended when several founders contribute capital, expertise, and management responsibilities.
Sole proprietorship	One person	Generally not recommended for this project due to the scale of investment, production activities, and potential business risks.

V.2. Main Registration and Compliance Steps

Table 0.2: Main administrative and compliance steps.

Step	Description
1	Select the legal form of the company (EURL or SARL) and reserve the business name "SAVIÉRA BioCosmetics".
2	Prepare the company's statutes, incorporation documents, and capital contribution records.
3	Register the company with the National Center of the Trade Register (CNRC).
4	Obtain the Tax Identification Number (NIF) and register with the relevant tax authorities.
5	Register employees and the company with the National Social Security Fund (CNAS/CASNOS).
6	Secure and prepare a compliant production facility in accordance with hygiene, safety, and manufacturing requirements.
7	Install production, laboratory, packaging, and storage equipment.

8	Develop cosmetic formulations and prepare complete Product Information Files (PIFs), including formulas, ingredient lists, labeling information, safety data, batch records, and quality-control documentation.
9	Conduct quality-control, stability, and safety testing before commercialization.
10	Verify and comply with all regulatory requirements related to cosmetic manufacturing, packaging, labeling, and commercialization in Algeria.
11	Establish Good Manufacturing Practices (GMP), hygiene procedures, traceability systems, and quality-control protocols.
12	Launch pilot production batches and validate manufacturing processes.
13	Begin commercial production, marketing, and distribution activities through B2C and B2B channels.

Note: The exact procedure for cosmetic manufacturing and marketing must be verified with the Ministry of Trade and competent control services before commercialization.

V.3. Tax and Support Mechanisms

The project may seek support from entrepreneurship structures such as CDE and NESDA. Possible support may include training, guidance, and financing mechanisms for micro-enterprises. However, the exact fiscal advantages, exemptions, customs reductions, and eligibility conditions may change and must be verified through official sources before inclusion in the final financial plan.

V.4. Product Safety and Labelling Requirements

Cosmetic-product commercialization requires strong attention to product safety. Natural origin does not automatically guarantee safety, because plant extracts and essential oils can cause irritation, allergy, or instability if used at unsuitable concentrations. The project should prepare clear labels, batch numbers, ingredient lists, expiry dates, storage instructions, warning statements, and directions for use.

Table 0.3: *Recommended product-label information.*

Label element	Purpose
Product name	Identifies the product and its cosmetic function.
Ingredients	Lists the product ingredients.
Net Quantity	Indicates product weight or volume.
Directions for Use	Explains how to use the product correctly.
Net quantity	Weight or volume

Warnings	Provides safety and precautionary information.
Batch Number	Ensures product traceability and quality control.
Manufacture/Expiry Date	Indicates product shelf life.
Producer Information	Provides company name and contact details.
Barcode	Facilitates product identification and retail sales.

V.5. Ethical and Safety Limits of the Project

The enterprise must avoid presenting cosmetic products as medicines. Claims such as treating diseases, curing infections, or eliminating medical conditions must not be used unless supported by the appropriate regulatory authorization. For example, the 'wart-care' prototype should be presented cautiously as a keratolytic skin-care formulation until proper medical and regulatory validation is obtained.

General Conclusion

The feasibility study of SAVIÉRA BioCosmetics demonstrates the potential viability of establishing a small-scale cosmetic manufacturing factory in Algeria. The project is designed to meet the growing demand for high-quality, natural, and scientifically formulated cosmetic products while supporting local industrial development and reducing dependence on imported products. The market analysis revealed promising opportunities within both the Business-to-Consumer (B2C) and Business-to-Business (B2B) segments, particularly through partnerships with pharmacies, beauty salons, cosmetic retailers, wholesalers, and distributors. The proposed product portfolio, led by Under Glow, HairLess, and Therapeutic Charcoal Soap, provides a strong foundation for market entry and future expansion.

The technical study confirmed the feasibility of production using appropriate manufacturing equipment, quality-control procedures, and qualified personnel. The project's phased development strategy allows for gradual product diversification and operational growth while maintaining manageable investment requirements. From a financial perspective, the project shows attractive profitability potential, a reasonable break-even point, and a satisfactory payback period. Sensitivity analysis further indicates that the business remains financially sustainable under different operating conditions.

Overall, SAVIÉRA BioCosmetics represents a promising entrepreneurial venture capable of generating economic value, creating employment opportunities, and contributing to the development of the Algerian cosmetics industry. With effective management, strong quality standards, and a customer-oriented marketing strategy, the company can establish a sustainable competitive position and achieve long-term growth in both local and regional markets.

Appendix A: Scientific Results Integrated into the Project

Table 0.1: Scientific results used for enterprise development.

Experimental information	How it supports the business project
Oil/aqueous balance	Supports the development of stable creams with suitable texture and spreadability.
Solubility/dispersion test	Assists in ingredient selection and formulation design.
Centrifugation/miscibility test	Evaluates formulation stability and resistance to phase separation.
pH and bromothymol blue test	Supports skin compatibility assessment and product safety.
Long-term visual stability	Monitors color, odor, texture, and product integrity during storage.
Preliminary skin tolerance	Provides initial information regarding product acceptability and safety.
DPPH assay	Evaluates antioxidant activity of natural ingredients and formulations.
Soap pH/free alkali/foam	Assesses soap quality, safety, cleansing performance.

Appendix B: Recommended Product Launch Sequence

Table 0.1: Proposed product launch sequence.

Launch phase	Products	Reason
Phase 1 (2026 – 2027)	Under Glow, HairLess, and Therapeutic Charcoal Soap	Core products with strong market demand, moderate production complexity, and high potential for both B2C and B2B sales.
Phase 2 (2028)	Antiperspirant Foot Cream and Antiperspirant Foot Gel	Utilizes existing production equipment and several common raw materials while expanding the personal-care product portfolio.
Phase 3 (2029)	Pre-Depilatory Exfoliating Cream and Post-Depilatory Soothing Cream	Complements the HairLess product line and creates a complete depilatory-care product range.
Phase 4 (2030)	Chlorophyllin Cosmetic Ingredient and Natural Active Ingredients Line	Supports diversification into industrial B2B markets and enables supply to cosmetic manufacturers and private-label brands.

References and Sources

- CNRC / Sidjilcom: official information on the Trade Register and company registration procedures in Algeria.
- AAPI: official guidance on company creation and the requirement to register new companies with CNRC.
- NESDA: official entrepreneurship and micro-enterprise support agency information.
- Algerian Customs / Ministry of Trade: information indicating that cosmetic and personal hygiene products may require prior authorization or regulatory control.
- ISO 22716: Cosmetics - Good Manufacturing Practices (GMP) guidelines for cosmetic production, to be consulted for implementation.



Approval for Final Printing of a Master's Dissertation

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Examiner 1	Mohammed Aouf	
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Thesis Title: Extracting bioactive compounds from medicinal plants for cosmetic applications

Hereby authorize the above-mentioned student(s) to print and submit their final manuscript to the department.

President of the jury

Ghardaia : 30/ 09/ 2026

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