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**Extraction and Characterization of *Anabasis articulata*
Extract and Its Application in the Development of Anti-
Inflammatory and Antioxidant Soap and Cream
Formulations**

Publicly defended in front of the the jury composed of:

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Dedication

Not every absence is forgotten; some absences remain forever in the heart, like a prayer and like love.

****To My Father...**b>**

To the first source of support I ever knew, and the first heart that gave me a sense of security.

You left before witnessing this day, yet you were present in every step that led me here.

Whenever I felt exhausted, I remembered your face, and whenever life became difficult, I recalled that you raised me to be strong. I dedicate this achievement to you, hoping that my joy reaches you wherever you are, in the vast mercy of Allah.

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List of Abbreviations and Symbols

Aa : *Anabasis articulata*

TPC:Total Phenolic Content

GAE:Gallic Acid Equivalent

DPPH: 2,2-Diphenyl-1-picrylhydrazyl

UAE:Ultrasound-Assisted Extraction

UV-Vis:Ultraviolet–Visible Spectrophotometry

AlCl₃:Aluminum Chloride

FeCl₃:Ferric Chloride

NaOH :Sodium Hydroxide

Na₂CO₃:Sodium Carbonate

HCl:Hydrochloric Acid

CHCl₃:Chloroform

H₂SO₄:Sulfuric Acid

MHA:Mueller–Hinton Agar

CFU:Colony Forming Unit

PBS Phosphate Buffered Saline

SAP:Saponification Value

pH:Potential of Hydrogen

IC₅₀:Half Maximal Inhibitory Concentration

ROS:Reactive Oxygen Species

INRAA:National Institute of Agronomic Research of Algeria

Rpm:Revolutions Per Minute

Mg:Milligram

Ml:Milliliter

Mg:Microgram

Mm:Millimeter

°C:Degree Celsius

General Introduction

Medicinal plants have long been recognized as an important source of bioactive compounds with significant therapeutic potential. In recent years, increasing scientific attention has been directed toward plant-derived natural products due to their ability to provide safer and more effective alternatives for the prevention and treatment of various diseases. These biological effects are mainly attributed to secondary metabolites such as phenolic compounds, flavonoids, tannins, and alkaloids, which are widely distributed in medicinal plants and are known for their antioxidant, anti-inflammatory, and antimicrobial properties (Talhouk et al., 2007; Pizzino et al., 2017).

Oxidative stress results from an imbalance between reactive oxygen species (ROS) production and the antioxidant defense system of the body. This imbalance can lead to cellular damage affecting lipids, proteins, and DNA, and is involved in the development of several chronic diseases, including inflammatory disorders, cancer, diabetes, and neurodegenerative diseases (Pizzino et al., 2017). Therefore, natural antioxidants derived from plants have become a major focus of research due to their ability to neutralize free radicals and reduce oxidative damage.

Inflammation is a natural protective response of the body against harmful stimuli; however, excessive or prolonged inflammation can lead to tissue damage and contribute to the progression of many pathological conditions. In this context, plant-based compounds have demonstrated promising anti-inflammatory activities by modulating key biochemical pathways involved in the inflammatory response. Moreover, oxidative stress and inflammation are closely interconnected processes, where oxidative damage can further amplify inflammatory reactions.

In addition to inflammatory disorders, microbial infections also represent a major health concern, particularly in skin diseases. The emergence of resistant bacterial strains has increased the need for new antimicrobial agents, especially from natural sources. Plant extracts containing phenolic-rich compounds have shown significant antibacterial activity against a wide range of pathogenic microorganisms, making them promising candidates for therapeutic applications.

Among medicinal plants, *Anabasis articulata* (Forssk.) Moq., belonging to the family *Amaranthaceae*, is a halophytic species widely distributed in arid and semi-arid regions. It has been traditionally used in folk medicine for the treatment of inflammatory conditions, skin diseases, and infections. Previous phytochemical investigations have revealed that this species is rich in secondary metabolites, including phenolic compounds and flavonoids, which are responsible for its reported biological activities such as antioxidant, anti-inflammatory, antibacterial, and antidiabetic effects (Al-Joufi et al., 2022; Shegebayev et al., 2024).

Given these pharmacological properties, *Anabasis articulata* represents a promising natural resource for the development of dermocosmetic and pharmaceutical formulations. Therefore, the present study aims to investigate the phytochemical composition of the ethanolic extract of *A. articulata* and to determine its total phenolic content. The antioxidant activity was evaluated using the DPPH radical scavenging assay, while the anti-inflammatory activity was assessed through the inhibition of protein (egg albumin) denaturation method. In addition, the antibacterial activity of the extract was tested against selected bacterial strains.

Furthermore, the extract was incorporated into topical formulations, including an anti-inflammatory cream and a medicinal soap, in order to explore its practical application in dermocosmetic products. These formulations were then subjected to physicochemical evaluation to assess their quality, stability, and suitability for potential therapeutic use.

Finally, the prepared formulations were evaluated in a preliminary in vivo study on volunteers suffering from mild inflammatory skin conditions, in order to assess their potential effectiveness and skin tolerance under practical use conditions.

Keywords: *Anabasis articulata*; Phenolic compounds; Antioxidant activity; Anti-inflammatory activity; Antibacterial activity; Herbal cream; Medicinal soap; Dermocosmetic formulations; Phytochemical screening; Skin inflammation.

Parte I: Literature Review

Chapter one :

Scientific study of the plant

An overview of medicinal plantsⁱ:

Medicinal plants have seen a surge in popularity in modern medicine thanks to their wide availability and low cost, as well as their safety compared to synthetic chemical drugs (World Health Organization, 2013). Medicinal plants are defined as plants containing bioactive secondary metabolites such as flavonoids, terpenoids, and alkaloids, which have been used to treat and prevent diseases since ancient times. These plants form the basis of traditional medicine in most cultures, with an estimated 80% of the population in the developing world relying on them, and around 25% of modern medicines being derived from plants (David J. Newman & Gordon M. Cragg, 2016). The irregular use of antibiotics, conventional medicines and certain external factors has exacerbated complex inflammatory conditions (Journal of Ethnopharmacology, 2020). This highlights the urgent need to standardise the scientific criteria for plant-derived medicines, paving the way for a transformative era in healthcare based on 'active plant compounds. Recent scientific interest in medicinal plants has increasingly focused on validating traditional remedies through pharmacological evidence. In this context, *Anabasis articulata* has been traditionally used in folk medicine for the treatment of inflammatory disorders, including skin irritations, rheumatic pain, and swelling. This ethnomedicinal use is strongly supported by recent experimental studies demonstrating that extracts of *A. articulata* exhibit significant anti-inflammatory and antioxidant activities, largely attributed to its rich content of flavonoids, alkaloids, and terpenoids (Boutrifa et al., 2024; Ben Mennia et al., 2024). Furthermore, in vivo studies have shown that bioactive fractions from this plant can reduce inflammatory responses in experimental models, suggesting a modulation of key inflammatory mediators (Boutrifa et al., 2024). In addition, recent reviews on the genus *Anabasis* confirm its pharmacological potential, highlighting consistent antioxidant and anti-inflammatory effects across different species, thereby reinforcing the link between traditional usage and modern scientific validation (Al-Joufi et al., 2022; Amtaghri et al., 2025). Overall, these findings support the growing scientific effort to standardize plant-derived therapies and isolate active compounds responsible for anti-inflammatory activity.

I. Famille des *Chenopodiaceae*:

The "*Chenopodiaceae*" family is a cosmopolitan family with an extremely wide geographic distribution, occurring simultaneously in distant regions such as the deserts of Eurasia and Australia. The family is also widely distributed across thousands of saltwater and subtropical habitats throughout the world, particularly around the Mediterranean, the Caspian Sea, and the Red Sea, in the steppes of Central and East Asia, and in the pampas of Argentina, which points to its ancient origins (Genetika, 2022; Systematic Biology, 2020); its pollen fossils date back to the Maastrichtian epoch, making it the oldest among all members of the order "*Caryophyllales*" (Palynology, 2020; Review of Palaeobotany and Palynology, 2018). Molecular and morphological studies show that it is closely related to the "*Amaranthaceae*" family; indeed, some scientific opinions suggest merging the two families (Angiosperm Phylogeny Group, 2016; Systematic Biology, 2020). This family is classified into two main tribes based on the shape of the embryo: The first is the tribe "*Cyclolobeae*", characterized by a semicircular or ring-shaped ovule surrounding the endosperm (Palynology, 2023; PhytoKeys, 2018). It includes genera that grow in temperate or subtropical regions, such as "*Chenopodium*" and "*Atriplex*", as well as herbaceous species that grow in brackish water, such as *Salicornia*, and edible species like lamb's quarters and spinach (World Flora Online, 2022; Plants of the World Online, 2023). The second is the tribe "*Spirolobeae*", characterized by a spiral embryo and an absent or divided endosperm, and comprising mainly plants of the steppes and coastal marshes, such as the genera *Salsola*, *Anabasis*, *Haloxylon*, and *Suaeda* (Palynology, 2023; Systematic Botany, 2017).



Figure 1 :

Figure (01): Global distribution of the family Chenopodiaceae (currently included within Amaranthaceae). The orange-colored areas represent the main regions where members of this family are naturally distributed, particularly in arid, semi-arid, and saline ..environment

II. The genus *Anabasis* :

Anabasis is a botanical genus belonging to the subfamily *Salsoloideae*, tribe *Salsoleae*, within the family *Amaranthaceae* (formerly *Chenopodiaceae*) (Hernández-Ledesma et al., 2015). The genus comprises approximately 28 species and is widely distributed in arid and semi-arid regions, particularly across North Africa, the Mediterranean Basin, and Central and Western Asia (Kadereit et al., 2017). Species of this genus commonly inhabit deserts, steppes, and saline environments and exhibit remarkable adaptations to drought and high salinity conditions. Among the most common and well-known species is *Anabasis articulata*, which is widely distributed in desert areas of North Africa and the Middle East and has attracted considerable scientific interest because of its richness in bioactive secondary metabolites and its traditional medicinal applications (Mimouni et al., 2021).

III. Morphological description of the plant *Anabasis articulata*:

Anabasis articulata is a perennial desert shrub adapted to harsh saline and arid environments characterized by high temperatures and drought conditions (Atlas Floristique Ecosystème, 2010). The plant usually reaches a height of 20–40 cm and plays an important ecological role in sand stabilization in desert soils. It is characterized by slender, erect, and highly branched stems, with secondary branches becoming rapidly erect. The stems are dark green and turn black upon drying, with elongated internodes ranging from 0.8 to 3 cm in the lower parts of the plant.

The plant possesses articulated and twisted stems and appears almost leafless during the dry season. Its leaves are opposite, reduced, and provided with a very short free lobe ending in a whitish tip. The inflorescences are short and clustered at the ends of the branches. The fruits are enclosed by three membranous double wings, which facilitate seed dispersal. *Anabasis articulata* commonly grows in rocky and sandy soils throughout the Sahara Desert, particularly in southern Saharan regions (TH5183, n.d.)

- **Common name:**

It is known as al-Ajram in the Middle East and al-Baqil in Algeria.



Figure 2 A



Figure 3 B



Figure 4 C

Figure 02: Morphological characteristics and natural habitat of *Anabasis articulata*: (A) General habit of the plant in its natural environment; (B) Detailed view of the aerial parts showing the highly branched structure and reduced leaves; (C) Branches of *Anabasis articulata* in a desert environment pictured by G.Imane BENAMMAR

IV. Scientific classification of the plant: The plant *Anabasis articulata*, commonly known as al-Baqil (ajram), is listed in the table :

Kingdom	Plantae
Phylum	Spermatophyta
Clade	Angiosperms
Order	Caryophyllales
Family	Chenopodiaceae\ Amaranthaceae
Subfamily	Salsoloideae
Genus	Anabasis
Species	Articulata

- Synonyms:**
 - ✓ *Anabasis mauritanica*
 - ✓ *Anabasis aphylla*
 - ✓ *Salsola articulata*
 - ✓ *Haloxylon articulatum*
 - ✓ *Haloxylon mauritanicum*

V. Traditional Medicinal Uses of *Anabasis articulata*:

Anabasis articulata has long been used in traditional medicine because of its various therapeutic properties. The plant is commonly prepared as a decoction to relieve stomach pain and manage diabetes. Its aerial parts are also applied as poultices after boiling for the treatment of several skin disorders, including eczema, psoriasis, and pediculosis, as well as fever (Makhlouf et al., 2025). In addition, the plant has traditionally been used to treat respiratory diseases such as asthma, rheumatism, and kidney disorders. In Algeria, Syria, and Iraq, *A. articulata* was historically employed as a poultice for the treatment of scabies (Makhlouf et al., 2024). These traditional uses may be related to the presence of various bioactive secondary metabolites, such as flavonoids, saponins, alkaloids, and phenolic compounds, which are known for their antioxidant and anti-inflammatory activities.

VI. Bibliographic Survey:
1. Study 01:

Several recent studies have investigated the biological activities of *Anabasis articulata* extracts. In 2024, Yasmine Makhlouf evaluated the antioxidant and anti-inflammatory activities of the ethanolic extract prepared from powdered flowers and leaves using a hydroethanolic solvent system (70:30, ethanol/water, v/v). The study demonstrated a strong free radical scavenging capacity and a significant reduction in oxidative stress and inflammation following oral administration (Makhlouf et al., 2024).

2. Study 02:

In another study conducted in 2024, the same researcher investigated the aqueous extract obtained by infusing powdered leaves and stems in boiling distilled water. The results revealed remarkable antioxidant activity and significant anti-inflammatory effects, particularly at an oral dose of 200 mg/kg (Makhlouf et al., 2024).

3. Study 03:

Azza M. and collaborators examined the hepatoprotective effect of the ethanolic extract against dimethylnitrosamine-induced liver injury and fibrosis in mice. Their findings demonstrated that the extract effectively alleviated hepatic damage in vivo through the inhibition of oxidative stress and inflammatory responses.

4. Study 04:

Fakhria A. Al-Jouf and colleagues investigated the antioxidant and antibacterial activities of the methanolic extract, concluding that it exhibits potent antioxidant potential alongside promising antibacterial effects.

Conclusion

Moreover, other pharmacological investigations have reported that *A. articulata* extracts possess additional bioactivities, including antimicrobial, cytotoxic, and anti-inflammatory properties, which are mainly attributed to its richness in secondary metabolites such as flavonoids, saponins, and phenolic compounds. These findings further support the ethnopharmacological use of the plant and highlight its potential as a source of natural therapeutic agent

VII. Secondary metabolites of *Anabasis articulata*:

Anabasis articulata is characterized by a rich and diverse phytochemical profile composed of several classes of secondary metabolites, which contribute to its pharmacological activities and adaptation to extreme desert environments. The main groups identified include alkaloids, flavonoids, phenolic compounds, saponins, tannins, terpenoids, and steroids. Each class comprises different subtypes with specific biological roles.

Alkaloids: The plant contains nitrogenous alkaloids, mainly including phenethylamine derivatives as well as salsoline- and salsolidine-type alkaloids commonly reported in *Anabasis* species, which are associated with antimicrobial, neuroactive, and anti-inflammatory properties (Al-Joufi et al., 2022; Boutrif et al., 2024).

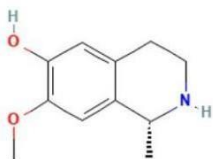


Figure 02: Salsoline structure

Flavonoids: *A. articulata* is rich in flavonoid derivatives, particularly flavonols and flavones such as quercetin and kaempferol-related compounds. These metabolites are major contributors to the strong antioxidant activity

of the plant due to their ability to scavenge free radicals and reduce oxidative stress (Ben Menni et al., 2024; Al-Joufi et al., 2022).

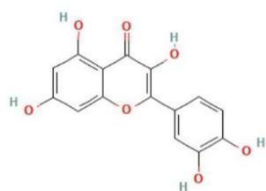


Figure03:Quercetin structure

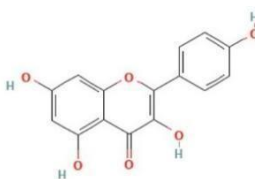


Figure 04:Kaempferol structure

Phenolic compounds: Various phenolic acids such as gallic acid, caffeic acid, and ferulic acid derivatives have been reported. These compounds play an important role in antioxidant, hepatoprotective, and anti-inflammatory activities (Ben Menni et al., 2024).

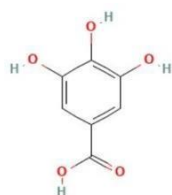


Figure 05 :Acid Galic structure

Saponins: Triterpenoid saponins are present and are characterized by their amphiphilic nature. They contribute to membrane interaction and are associated with antimicrobial, anti-inflammatory, and immunomodulatory effects (Al-Joufi et al., 2022).

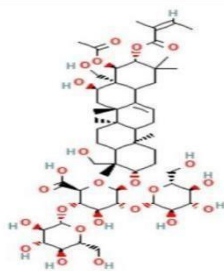


Figure 06:Saponin structure

Tannins: Both hydrolysable and condensed tannins may be present in the plant. These polyphenols exhibit strong protein-binding capacity and are responsible for antioxidant, antimicrobial, and astringent properties (Al-Joufi et al., 2022).

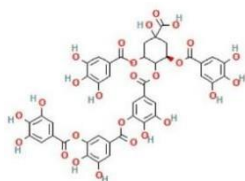


Figure 07:Hydrolysable tannins structure

Terpenoids: The plant contains mono-, sesqui-, and possibly triterpenoids, which play roles in plant defense mechanisms and are linked to anti-inflammatory and cytotoxic activities (Ben Menni et al., 2024).

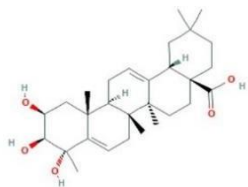


Figure 08:Triterpenoids structure

Steroids: Phytosterols have also been reported in *A. articulata*, including compounds such as β -sitosterol and related sterol derivatives. These molecules are known for their membrane-stabilizing properties and potential anti-inflammatory and antioxidant effects (Al-Joufi et al., 2022).

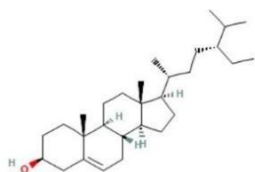


Figure 09: β -sitosterol structure

Coumarins: Coumarin derivatives have also been detected in *A. articulata*. These compounds are known for their antioxidant, anticoagulant, and anti-inflammatory activities, and they may contribute to the overall pharmacological profile of the plant through free radical scavenging and enzyme inhibition mechanisms (Ben Menni et al., 2024).

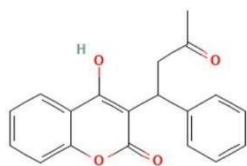


Figure 10: Coumarin structure

Overall, the synergy between these secondary metabolite classes explains the wide spectrum of biological activities reported for *Anabasis articulata*, supporting its traditional medicinal uses and its potential as a source of bioactive natural compounds (Ben Menni et al., 2024; Boutrif et al., 2024).

Chapter tow

Antioxidant , Anti-inflammatory and Antibacterial Activities of *Anabasis articulata*

Antioxidant Activities:

I. Free radicals:

Free radicals are atoms or molecules that contain at least one unpaired electron in their outer orbit, making them highly unstable and reactive (Martemucci et al., 2022). Such reactive species are generated through various biochemical reactions, particularly those involving oxygen metabolism and electron transfer processes (Halliwell, 2024). Due to their instability, free radicals readily react with biomolecules such as proteins, lipids, and DNA, leading to structural and functional cellular damage (Nitti et al., 2022). Free radicals may originate from endogenous sources, including metabolic processes and inflammation, or from exogenous sources such as pollution, radiation, and toxic chemicals (Iakovou & Kourti, 2022)

II. Oxidative stress:

1) Definition :

Oxidative stress is defined as an imbalance between the production of reactive oxygen species (ROS) and the ability of biological antioxidant systems to neutralize these reactive compounds or repair the damage they cause (Sies, 2015). This imbalance may result either from excessive oxidant production or from a reduction in antioxidant defense mechanisms, leading to the accumulation of free radicals inside cells.

2) Biological Effects of Oxidative Stress:

Excessive oxidative stress causes damage to essential cellular components such as lipids, proteins, and DNA. Contributing to the development of several chronic diseases including diabetes, cardiovascular disorders, neurodegenerative diseases, and inflammation (Martemucci et al., 2022). Oxidative stress is also closely associated with inflammatory responses because reactive oxygen species stimulate inflammatory pathways and increase tissue injury.

3) Antioxidant Role of *Anabasis articulata*:

Medicinal plants rich in antioxidant secondary metabolites have attracted considerable scientific interest due to their ability to reduce oxidative damage. Among these plants, *Anabasis articulata* has shown promising antioxidant activity attributed to its richness in flavonoids, phenolic compounds, carotenoids, coumarins, and alkaloids. These compounds contribute to the scavenging of free radicals and protection of cellular structures against oxidative stress (Shahidi & Ambigaipalan, 2015).

III. Types of Free Radicals

Free radicals are classified according to their chemical nature into reactive oxygen species (ROS) and reactive nitrogen species (RNS).

Reactive oxygen species include superoxide anion ($O_2^{\bullet-}$), hydroxyl radical ($\bullet OH$), and peroxy radical ($ROO\bullet$). Hydrogen peroxide (H_2O_2), although not considered a free radical itself, contributes significantly to free radical generation inside cells (Sies, 2015; Reuter et al., 2010).

Reactive nitrogen species include nitric oxide (NO•) and peroxynitrite (ONOO[−]), which participate in several physiological and inflammatory processes (Sies, 2015). Among these reactive species, the hydroxyl radical is considered one of the most damaging because of its extremely high reactivity toward cellular components (Jomova et al., 2024).

The antioxidant activity of *Anabasis articulata* is mainly related to its ability to neutralize these reactive species through the action of flavonoids, carotenoids, and other phenolic compounds present in the plant.

IV. Mechanisms of Free Radical Formation

Free radicals are formed through several biological and chemical mechanisms, including:

- Homolytic cleavage of covalent bonds: This process produces two radicals, each retaining one electron from the original bond (Halliwell & Gutteridge, 2015).
- Redox reactions: Electron transfer reactions occurring during mitochondrial respiration and cellular metabolism may generate reactive oxygen species (Sies, 2015).
- Enzymatic reactions: Certain enzymes such as NADPH oxidase and xanthine oxidase contribute to ROS production (Sies, 2015).
- External factors: Exposure to pollutants, radiation, toxic chemicals, and cigarette smoke may increase free radical formation in biological systems (Liguori et al., 2018).

Environmental stress conditions such as drought and salinity also stimulate the synthesis of antioxidant secondary metabolites in desert plants such as *Anabasis articulata*, enhancing their protective biological activities.

V. Diseases Associated with Free Radicals

Excessive production of free radicals and oxidative stress contributes to the development of numerous diseases due to oxidative damage affecting cellular structures.

- Neurodegenerative diseases: Oxidative stress contributes to neuronal degeneration associated with diseases such as Alzheimer's and Parkinson's disease (Halliwell & Gutteridge, 2015; Liguori et al., 2018; Singh et al., 2019).
- Cardiovascular diseases: Free radicals promote oxidation of low-density lipoproteins (LDL), contributing to atherosclerosis and cardiovascular disorders (Habtemariam, 2019).
- Cancer: Reactive oxygen species (ROS) may induce DNA mutations and disrupt cellular repair mechanisms, contributing to carcinogenesis (Reuter et al., 2010; Hayes et al., 2020).
- Diabetes: Oxidative stress is associated with insulin resistance and pancreatic β -cell dysfunction (Brownlee, 2001; Yaribeygi et al., 2019).
- Chronic inflammation: Free radicals stimulate inflammatory mediators and contribute to persistent inflammatory responses (Mittal et al., 2014; Sies & Jones, 2020).

VI. Antioxidants and Antioxidant Activity of *Anabasis articulata*:

Antioxidants protect cells against oxidative damage mainly through the neutralization of free radicals and the inhibition of oxidation reactions (Halliwell, 2024). Natural antioxidants present in medicinal plants, especially flavonoids, phenolic compounds, carotenoids, and tannins, play an important role in reducing oxidative stress and limiting cellular damage (Jomova et al., 2024). The antioxidant activity of AA is mainly attributed to its richness in these bioactive secondary metabolites, which contribute to free radical scavenging and protection against oxidative stress.

VII. Natural Antioxidants:

Natural antioxidants are bioactive compounds naturally found in plants, foods, and living organisms. They play a crucial role in protecting cells against oxidative damage induced by reactive oxygen species (ROS), which are involved in the pathogenesis of inflammation, aging, cardiovascular disorders, diabetes, and cancer (Sharifi-Rad et al., 2020).

Natural antioxidants include several classes of compounds differing in their chemical structures and mechanisms of action, mainly vitamins, phenolic compounds, carotenoids, and antioxidant enzymes.

Vitamins such as vitamin C and vitamin E are among the most important natural antioxidants. Vitamin C acts as a water-soluble antioxidant capable of scavenging free radicals in aqueous cellular environments, whereas vitamin E protects membrane lipids against peroxidation by interrupting oxidative chain reactions (Salehi et al., 2019).

Phenolic compounds, including flavonoids, phenolic acids, and tannins, represent one of the largest groups of plant antioxidants. Their antioxidant activity is mainly attributed to their ability to donate electrons or hydrogen atoms, chelate metal ions, and inhibit oxidative reactions. These compounds are widely distributed in medicinal plants and are strongly associated with anti-inflammatory and protective biological effects (Shahidi & Ambigaipalan, 2015).

Carotenoids such as β -carotene, lutein, and lycopene are lipid-soluble pigments that contribute to cellular protection by neutralizing singlet oxygen and other reactive species, thereby reducing oxidative damage in biological membranes (Bohn et al., 2021).

In addition, endogenous antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) constitute an important cellular defense system that converts harmful reactive species into stable and less toxic molecules such as water and oxygen (Ighodaro & Akinloye, 2018).

Overall, natural antioxidants are essential for maintaining cellular redox balance and preventing oxidative stress-related damage. Numerous antioxidant phytochemicals have been identified in medicinal plants such as *Anabasis articulata*, which may explain their significant antioxidant and anti-inflammatory activities.

B. Anti-inflammatory Activities :

I. Inflammation definition :

Inflammation is a process aimed at repairing damaged tissue and providing a self-defense mechanism against external factors such as pathogens and irritants; it is a complex immune response of the affected vascular tissues. (Kumar et al., 2015)

II. Inflammation Types: Inflammation is divided into two types:

- **Acute inflammation:** This is an immediate, primary response in which plasma cells and innate immune cells (phagocytes, etc.) migrate from the blood to the site of the response (Kumar et al., 2015).

- **Chronic inflammation:** A long-term response involving a gradual change in cell types, characterized by tissue destruction and subsequent healing. An example of this is atopic dermatitis (eczema), which leads to severe dryness and skin scaling due to a lack of lipids. (Kumar et al., 2015)

III. Causes of Inflammation: The inflammatory response is triggered by various invasive factors and stimuli, including

Pathogens: Such as microbes and bacteria. (Chen et al., 2018)

External Agents: Irritants, chemical substances, and mechanical agents. (Chen et al., 2018)

Internal Factors: Damaged cells and autoimmune responses. (Chen et al., 2018)

IV. Symptoms and Consequences of Inflammation:

Clinically, inflammation is characterized by several local and systemic manifestations including redness, swelling, heat, pain, itching, and loss of tissue function (Chen et al., 2018). Chronic inflammatory conditions may additionally affect the psychological and physiological well-being of patients, particularly in skin disorders such as eczema and psoriasis (Dalgard et al., 2015).

Persistent inflammation is strongly associated with oxidative stress because activated immune cells generate excessive reactive oxygen species capable of damaging proteins, lipids, and DNA. Consequently, chronic inflammation contributes to the development of several diseases including cancer, neurodegenerative disorders, cardiovascular diseases, and diabetes (Pizzino et al., 2017; Liguori et al., 2018). Due to its richness in antioxidant and anti-inflammatory secondary metabolites, *Anabasis articulata* represents a promising medicinal plant for reducing inflammation and protecting tissues against oxidative damage (Ben Menni et al., 2024; Boutrifa et al., 2024).

V. Inflammatory Mediators:

Inflammation is associated with the release of several chemical mediators such as cytokines, prostaglandins, leukotrienes, and nitric oxide, which contribute to redness, swelling, pain, and tissue damage (Barnes, 2016; Tanaka et al., 2014). Excessive production of these mediators may aggravate chronic inflammatory diseases and increase oxidative stress. (Pizzino et al., 2017)

Natural bioactive compounds present in medicinal plants can reduce inflammation through the inhibition of inflammatory mediators and free radical formation. In this context, *Anabasis articulata* is considered a promising medicinal plant due to its richness in flavonoids, phenolic compounds, coumarins, and carotenoids known for their antioxidant and anti-inflammatory activities (Ben Menni et al., 2024; Shahidi & Ambigaipalan, 2015).

VI. Anti-inflammatory Agents:

Anti-inflammatory agents are substances that suppress or regulate inflammatory responses caused by microbial infections, tissue injury, autoimmune disorders, degenerative diseases, or oxidative stress. Their main role is to reduce tissue damage, relieve inflammatory symptoms, and maintain physiological homeostasis during acute or chronic inflammation (Barnes, 2016)

Natural medicinal plants have attracted considerable scientific interest as alternative sources of anti-inflammatory compounds because of their biological effectiveness and relatively low toxicity (Khan et al., 2021). Among these plants, *Anabasis articulata* has shown promising anti-inflammatory potential due to its richness in flavonoids, phenolic compounds, saponins, carotenoids, and coumarins known for their protective biological activities (Ben Menni et al., 2024; Boutrifa et al., 2024)

VII. Mechanism of Action of Anti-inflammatory Agents :

Anti-inflammatory agents exert their activity through several mechanisms, including:

- Reduction of pro-inflammatory mediators such as cytokines and prostaglandins responsible for pain, redness, swelling, and tissue damage (Tanaka et al., 2014).
- Inhibition of inflammatory enzymes, particularly cyclooxygenase (COX), involved in prostaglandin synthesis (Sies, H., & Jones, D. P. (2020)).
- Reduction of oxidative stress and free radical production, which contribute significantly to the progression of inflammatory reactions (Sostres, C., & Gargallo, C. J. (2020))

Plant-derived secondary metabolites such as flavonoids and polyphenols possess both antioxidant and anti-inflammatory activities. These compounds can reduce cellular damage caused by reactive oxygen species and help regulate inflammatory responses. Several studies reported that *Anabasis articulata* exhibits important anti-inflammatory effects due to the presence of bioactive compounds capable of reducing oxidative stress and inhibiting inflammatory mediators (Makhlouf et al., 2024)

VIII. Types of Anti-inflammatory Agents: Anti-inflammatory agents are generally

classified into the following categories:

- **Nonsteroidal anti-inflammatory drugs (NSAIDs):** These drugs reduce inflammation by inhibiting cyclooxygenase enzymes involved in prostaglandin production (Vane et al., 2021).
- **Corticosteroids:** These compounds suppress inflammatory responses and reduce the production of inflammatory mediators (Barnes, 2016).
- **Biological agents:** These therapies target specific inflammatory mediators and are mainly used in chronic inflammatory diseases (Smolen et al., 2019).

- **Natural anti-inflammatory compounds:** These include plant-derived compounds such as flavonoids, polyphenols, carotenoids, and coumarins, which possess antioxidant and anti-inflammatory properties (Panche et al., 2016).

Because oxidative stress plays an important role in the initiation and progression of inflammation, antioxidant compounds may significantly contribute to anti-inflammatory activity. Therefore, medicinal plants rich in antioxidant secondary metabolites, such as *Anabasis articulata*, are considered promising natural therapeutic agents with potential pharmaceutical and cosmeceutical applications.

C. Antibacterial Activities:

I. I. Definition:

Bacteria are microscopic single-celled organisms found almost everywhere on Earth and play an essential role in ecosystems and biotechnology. They exist in different shapes, including spherical, rod-shaped, and spiral forms. While some bacteria are pathogenic and capable of causing diseases, many others are harmless or beneficial. In the human body, beneficial bacteria, particularly those inhabiting the digestive system, contribute to maintaining normal physiological functions and overall health. Some bacterial species are also able to survive under extreme environmental conditions such as high temperature and pressure (National Human Genome Research Institute, 2026)

II. Classification of bacteria: Bacteria are classified into several categories

1) In terms of the distribution of its branches:

- Monotrichous bacterium: A bacterium that possesses a single flagellum arising from one pole of the cell.
- Lophotrichous bacterium: A bacterium that bears a tuft (cluster) of flagella emerging from a single pole of the cell.
- Amphitrichous bacterium: A bacterium that has a single flagellum or a tuft of flagella at both poles of the cell.
- Peritrichous bacterium: A bacterium in which flagella are distributed uniformly over the entire cell surface.

2) In terms of form:

- Cocci: Bacteria whose cells appear as small spherical forms under the microscope.
- Coccobacilli: Bacteria whose cells appear as short, small rod-shaped forms under the microscope.
- Spiral bacteria (spirilla/spirochetes): Bacteria whose cells exhibit a helical or spiral morphology.
- Vibrio: Bacteria characterized by a curved, comma-shaped (V-like) morphology.

3) Based on their oxygen requirements and living environment:

- Aerobic bacteria: These bacteria grow and survive in the presence of atmospheric oxygen and are often associated with food spoilage and foodborne contamination. Example: *Neisseria* spp.
- Anaerobic bacteria: These bacteria grow only in the absence of atmospheric oxygen. Example: *Clostridium* spp.
- Facultative anaerobic bacteria: These bacteria are capable of growing in both the presence and absence of oxygen, adapting their metabolism accordingly. Example: *Escherichia coli* (*E. coli*).

4) From a nutritional point of view:

- Autotrophic bacteria: Bacteria that utilize inorganic carbon sources, such as carbon dioxide, for their growth and biosynthetic processes.
- Heterotrophic bacteria: Bacteria that obtain carbon from the degradation of organic compounds such as sugars and other organic matter.

5) Based on Gram staining (Gram's method, introduced by Hans Christian Gram in 1884), which differentiates bacteria according to differences in cell wall structure:

- **Gram-positive bacteria:** These bacteria retain the crystal violet stain during the Gram staining procedure and therefore appear purple/violet under the microscope. Their cell wall is characterized by a thick peptidoglycan layer.
- **Gram-negative bacteria:** These bacteria do not retain the crystal violet stain and instead take up the counterstain (safranin), appearing pink/red under the microscope. Their cell wall contains a thinner peptidoglycan layer and an outer membrane.

6) From the perspective of their impact on humans: bacteria can be classified into three main groups that differ in their role and health effects:

- **Beneficial bacteria:** These are microorganisms that naturally inhabit the intestines of humans and animals, where they perform essential functions such as aiding digestion and maintaining microbial balance within the body. They also help inhibit the growth of certain harmful microbes. In addition, they contribute to the production of several vitamins that are essential for the body. Beneficial bacteria are also used in industrial applications, such as the production of some dairy products. Soil-dwelling species play an important role in decomposing and breaking down the remains of dead organisms.
- **Opportunistic bacteria:** These bacteria normally live in the body without causing harm under healthy conditions; however, they may become pathogenic when the immune system is weakened or when the body's balance is disrupted. For example, if they multiply excessively in areas such as the throat beyond the body's ability to control them, they may cause infections such as sore throat or tonsillitis. Among opportunistic bacteria, we mention:

• ***Pseudomonas aeruginosa*:** is an opportunistic Gram-negative bacterium and an important model organism for studying virulence factors and bacterial social behaviors. It can be isolated in low numbers from a wide range of environments, including soil and water, but it is also commonly found in environments influenced by human and animal activity. It is a major cause of morbidity and mortality in immunocompromised and chronically ill patients. Infections caused by this bacterium are particularly difficult to treat due to multiple antibiotic resistance mechanisms, as well as its strong ability to form multicellular biofilms, which further enhance its persistence and resistance to treatment



Figure 5 : *Pseudomonas aeruginosa* bacteria under the microscope

Harmful bacteria: These are pathogenic bacteria capable of entering the human body through various routes such as the respiratory system, mouth, or skin, leading to a range of serious or infectious diseases, including cholera, leprosy, pneumonia, typhoid, and whooping cough. Among them, we mention:

• ***Staphylococcus aureus*:** is considered the most pathogenic among the commonly encountered staphylococcal species. It is a Gram-positive, spherical (coccus-shaped) bacterium that frequently causes skin infections. However, it can also lead to more severe conditions such as pneumonia, endocarditis (infection of the heart valves), and osteomyelitis (bone infections). In addition, some strains have developed resistance to certain antibiotics, making treatment more difficult.

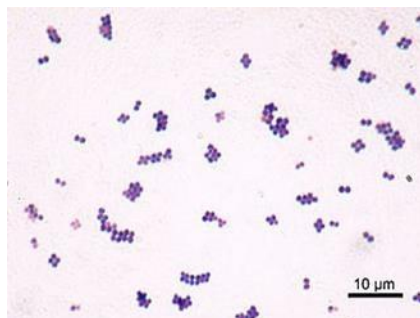


Figure 6 : *Staphylococcus aureus* bacteria under the microscope

Escherichia coli (E. coli): is a bacterium that inhabits the digestive tract of humans and warm-blooded animals. Most strains of *E. coli* are harmless, while only a few are pathogenic to humans. This is the case for enterohemorrhagic *E. coli* (EHEC) strains. EHEC strains are regularly responsible for food poisoning through the consumption of undercooked or raw animal products such as meat and dairy products. Fresh fruits and vegetables that have been contaminated with EHEC may also present a health risk. (Institut Pasteur, n.d.)



Figure 7 : *Pseudomonas aeruginosa* bacteria under the microscope

III. Choice of Bacterial Strains in Relation to Skin Infections:

These bacterial strains were selected due to their strong relevance to skin and soft tissue infections. *Staphylococcus aureus* is one of the main causative agents of skin infections such as acne, abscesses, wound infections, and cellulitis, making it a key model organism in dermatological antimicrobial studies. It is particularly important due to its ability to colonize the skin and its increasing resistance to multiple antibiotics, including methicillin-resistant strains (MRSA), which complicates treatment. In addition, *Escherichia coli*, although mainly associated with intestinal infections, can also be involved in secondary skin and wound infections, especially in cases of tissue damage or immunocompromised patients. *Pseudomonas aeruginosa* is also a significant opportunistic pathogen in burn wounds and chronic skin infections, where it exhibits strong biofilm-forming ability and high resistance to antibiotics, making infections persistent and difficult to eradicate. This selection therefore allows a comprehensive evaluation of the antibacterial potential of the plant extract against clinically relevant pathogens involved in skin-related infections.

IV. General Overview of Antibiotics:

Antibiotics are chemical compounds capable of killing bacteria or inhibiting their growth, and they are widely used in the treatment of bacterial infections. These compounds may be naturally produced by certain microorganisms such as fungi and bacteria, or they may be semi-synthetic or synthetic substances developed in laboratories to improve their therapeutic effectiveness. Antibiotics act through several mechanisms, including inhibition of bacterial cell wall synthesis and prevention of protein and nucleic acid production necessary for bacterial growth and reproduction. The discovery of penicillin by Alexander Fleming in 1928 is considered one

of the most important achievements in modern medicine, as antibiotics have significantly reduced infectious diseases and mortality rates. However, the excessive and inappropriate use of antibiotics has led to the emergence of antibiotic-resistant bacteria, which has become a major global health challenge (World Health Organization, 2023.)

V. Major Classes of Antibiotics Based on Their Mechanism of Action: (Carroll et al., 2019)

Antibiotics can be classified into several types according to their mechanism of action or chemical structure. The main categories include:

- **Cell wall synthesis inhibitors:** These antibiotics prevent the formation of the bacterial cell wall, leading to bacterial death. Examples include penicillins and cephalosporins.
- **Protein synthesis inhibitors:** They act on bacterial ribosomes and inhibit the production of proteins essential for bacterial growth, such as tetracyclines and macrolides.
- **Nucleic acid synthesis inhibitors:** These antibiotics interfere with DNA replication or RNA synthesis in bacterial cells. Examples include quinolones and rifampicin.
- **Cell membrane disruptors:** They damage the bacterial cell membrane, causing leakage of cellular contents and eventual cell death, such as polymyxins.
- **Metabolic pathway inhibitors:** These antibiotics block essential metabolic reactions required for bacterial survival, such as sulfonamides and trimethoprim.

VI. Microbial Susceptibility Testing:

Microbial susceptibility tests are used to evaluate the effectiveness of antibiotics in inhibiting or killing bacteria. The standard methods in this field are generally divided into two main categories:

❖ Microbiological methods:

These methods are based on cultivating bacteria on artificial culture media in order to assess the activity of antimicrobial agents. One of the most widely used techniques is the agar diffusion method, which is performed using different approaches, mainly the disk diffusion method and the radiating streak method. Among these, the disk diffusion method is the most commonly used in routine laboratory practice.

❖ Technical methods:

These methods involve modern and advanced techniques that are generally applied when rapid results are required or when microbiological methods are not sufficient. The main techniques include:

- Turbidity measurement
- Optical density measurement
- Measurement of metabolic activity

Chapter three

Cosmeceuticals , Medicated soap

A. Cosmeceuticals:

I. Cosmeceuticals:

Cosmeceuticals are cosmetic products containing biologically active ingredients capable of exerting a pharmacological effect on the surface of the skin. They are created not only for better appearance but also for concrete biological benefits that the skin receives. Cosmeceuticals are a bridge between cosmetics and pharmaceuticals, having both aesthetic and therapeutic properties. These products have a functional activity on the skin and are offered in different forms for care of skin, hair and body. They are often used to treat a variety of conditions including wrinkles, photoaging, dry skin, hyperpigmentation, uneven skin tone, dark spots and hair damage. (Draelos, 2015; Barel et al., 2014)

II. Types of cosmeceuticals : (Aziz et al., 2016)

- Skin Care Products: include moisturizers, retinoids, hydroxy acids (AHA & BHA), and skin brightening agents.
- Sun Care Products: include antioxidants (such as vitamins C and E) and chemical and physical sunscreens.
- Hair Care Products: include therapeutic shampoos, hair growth stimulators, and dandruff treatment.

III. Characteristics: (Aziz et al., 2016)

- It has a dual function of modifying the structure and function of the skin in addition to improving its appearance.
- One of the most prominent characteristics of these materials is that they are safe, effective, innovative, stable, and inexpensive to manufacture.

IV. Cosmeceutical Creams Classification:

Cosmeceutical creams are classified on the basis of different criteria, mainly texture, function and chemical composition as follows: (Draelos, 2015; Barel et al., 2014).

- **By consistency:** They are classified in three groups; light textured creams with a low viscosity for daily use; heavy textured creams with a high lipid content mostly for dry and sensitive skin and gel based formulations with a medium consistency mostly for oily skin .
- **By function:** These include moisturizing creams, cleansing creams, massage creams, night creams, emollient creams, foundation creams and protective creams.
- **By composition:** They are mostly classified into oil-in-water (O/W) emulsions which are lighter and more easily absorbed and water-in-oil (W/O) emulsions which offer a more occlusive barrier on the skin

V. Active natural bioactive compounds and their roles:

Cosmeceuticals contain biologically active substances such as vitamins, peptides, retinoids, antioxidants, and plant-derived bioactive molecules, including polyphenols, flavonoids, tannins, terpenoids, and essential oils. These natural and synthetic compounds have been attributed a number of therapeutic effects on the skin, such as anti-aging, anti-inflammatory, antimicrobial and skin-repair activities. They function by scavenging free radicals, reducing inflammation, promoting collagen synthesis, and shielding the skin from environmental stressors such as UV radiation and pollution (Draelos, 2015; Barel et al., 2014; Khan et al., 2021).

VI. Mechanism of action (Anti-Inflammatory mechanism):(Draelos, 2015; Barel et al., 2014; Khan et al., 2021; Gupta & Versteeg, 2017)

- **Enzyme Inhibition:** Plant extracts work to prevent the formation of “prostaglandins” and “leukotrienes,” the substances responsible for inflammatory symptoms such as redness and swelling.
- **Skin Tissue Protection:** Anti-inflammatory compounds protect connective tissues that aid in skin healing from enzymatic breakdown during irritation.
- **Immune Modulation:** Certain plant extracts help regulate the skin’s immune response to reduce sensitivity.
- **Skin barrier repair mechanism:** Certain plant-derived compounds enhance the integrity of the skin barrier by restoring lipid layers
- **Reducing oxidative stress:** Antioxidants (vitamins C and E) inhibit the activity of free radicals generated by UV rays before they trigger an inflammatory response in the dermis.
- **Regeneration Mechanism:** It exfoliates and balances skin texture, as fruit acids gently dissolve the bonds between dead cells, preventing clogged and inflamed pores (as in the case of acne), while “growth factors” stimulate the formation of new, healthy tissue to replace damaged tissue.

B. Soap:

I. Soap:

Soap is a cleansing agent used to remove dirt, grease, and impurities from the skin or other surfaces. It is chemically defined as the sodium or potassium salt of fatty acids, produced through the reaction of fats or oils with an alkali in a process known as saponification. Soaps are available in different forms depending on their composition and intended use(Hill, J. W., & Petrucci, R. H. 2017).

II. Soap classification:

- **Toilet soap:** Toilet soaps are widely used for daily skin cleansing and personal hygiene. They are formulated to efficiently remove dirt, sweat, and excess sebum while maintaining the natural balance of the skin and minimizing irritation (Barel et al., 2014).
- **Medicinal soaps:** Medicated soaps are formulated with biologically active ingredients intended to treat or manage various skin disorders such as acne, dermatitis, eczema, and microbial infections. In addition to their cleansing function, these soaps may exhibit antibacterial, moisturizing, antioxidant, and soothing properties (Draelos, 2015).
- **Antiseptic soap:** Antiseptic soaps are designed to inhibit or reduce the growth of microorganisms on the skin. They are commonly used in both domestic and healthcare settings to maintain hygiene and reduce the risk of infections (Barel et al., 2014).
- **Glycerin soap:** Glycerin soaps contain humectant agents, mainly glycerol, which help attract and retain moisture in the skin. Due to their mild and moisturizing properties, they are particularly suitable for dry and sensitive skin (Barel et al., 2014).

III. Medicated soap :

Medicated soap is a therapeutic cleansing product that combines cleansing activity with pharmacological or biological effects. It is commonly used to support the management of several skin conditions, including acne, dermatitis, eczema, itching, seborrhea, dry skin, and skin irritation. In addition to cleansing, medicated soaps may provide moisturizing, emollient, antibacterial, antioxidant, and anti-inflammatory effects.

Recently, increasing attention has been directed toward the incorporation of plant-derived extracts into medicated soap formulations to enhance their therapeutic potential (Devi et al., 2021). Medicinal plants are rich in bioactive compounds such as polyphenols, flavonoids, terpenoids, alkaloids, and essential oils, which are associated with several biological activities including antioxidant, anti-inflammatory, antimicrobial, and skin-soothing effects (Kulik-Siarek et al., 2024; Raj et al., 2025).

These plant-derived compounds may contribute to skin protection by reducing oxidative stress, inhibiting microbial growth, and modulating inflammatory responses. Consequently, the incorporation of herbal extracts into medicated soaps can improve both cleansing performance and therapeutic efficacy, particularly in the management of skin disorders such as acne, dermatitis, and irritation (Devi et al., 2021; Kulik-Siarek et al., 2024).

VII. Types of medicated soaps:

Medicated soaps are also distinguished by their purpose and active ingredients (Barel et al., 2014; Draelos, 2015).

1. **Antibacterial soaps:** These soaps are used for hygiene and medical purposes and widely used to reduce or prevent microbial growth on skin (Barel et al., 2014).
2. **Soap for Acne:** They are used to control sebum production, unclog pores, limit microbial growth and prevent and treat acne (Draelos, 2015; Gupta & Versteeg, 2017)
3. **Soaps with anti-inflammatory properties:** These soaps work great to reduce inflammation and calm down skin irritation. They are commonly used for conditions such as acne, eczema and dermatitis and often contain natural bioactive compounds such as polyphenols, flavonoids and essential oils with anti-inflammatory and antioxidant properties (Khan et al., 2021; Draelos
4. **Syndicate (synthetic detergent) bars:** These are mild cleansing agents, based on synthetic surfactants, and are suitable for sensitive or damaged skin, because of their low irritation potential (Barel et al., 2014)
5. **Speciality soaps:** This category includes soaps for special needs, such as soaps for sensitive skin, transparent soaps with high humectants (e.g., glycerin), and superfatted soaps with extra lipids for reduced dryness (Barel et al., 2014).

VIII. Medicated Soap Manufacturing Process: The preparation of medicated soap involves several well-defined steps to ensure the stability, safety, and efficacy of the final product (Barel et al., 2014).

- **Selection of raw materials:** Appropriate fats and oils, such as coconut oil or olive oil, are selected based on their physicochemical properties, which influence the hardness, foaming capacity, and moisturizing effect of the soap.
- **Saponification:** The process begins with the reaction of fats or oils with an alkali, typically sodium hydroxide, resulting in the formation of soap and glycerol (Wells, 2012). This step requires careful control of temperature and proportions to ensure complete reaction.

- **Soap base preparation:** The soap mass is further processed, purified, and refined to obtain a homogeneous and stable base suitable for formulation (Barel et al., 2014).
- **Incorporation of active ingredients:** Medicated or biologically active substances, such as antiseptics, plant extracts, or vitamins, are incorporated after partial cooling of the soap base to prevent thermal degradation (Draelos, 2015).
- **Addition of excipients:** Auxiliary substances such as fragrances, colorants, preservatives, and humectants (e.g., glycerin) may be added to improve the sensory and functional properties of the soap (Almukainzi et al., 2022).
- **Mixing and homogenization:** The formulation is thoroughly mixed to ensure uniform distribution of all components, particularly the active ingredients (Maculan et al., 2025).
- **Molding and shaping:** The prepared soap is poured into molds and shaped into the desired form (Maculan et al., 2025).
- **Drying and curing:** The soap is allowed to dry and cure for a specific period to enhance hardness, stability, and overall quality (Maculan et al., 2025).
- **Quality control:** The final product undergoes quality assessment, including pH determination, stability testing, and evaluation of antimicrobial efficacy, to ensure safety and effectiveness (Maculan et al., 2025).
- **Packaging:** Finally, the soap is packaged under hygienic conditions to preserve its quality and prevent contamination (Maculan et al., 2025).

IX. soap-making methods:

- This process is carried out industrially in several ways, most notably

- **the hot method :** This method is carried out in two stages. (Dunn, K. 2010)

Stage 1: The glycerides (fats) are heated to about 80°C. Then, the lye-based substance is gradually added while stirring continuously and boiling for several hours until a sticky paste containing soap, glycerol, and sodium salts is produced.

Stage 2: Soap separation: The paste is left to cool for 12 hours, then a concentrated brine solution (table salt) is added. The soap, containing glycerol and impurities, floats on top of the brine solution. To increase the purity of the soap, it is boiled several times in a concentrated brine solution to reduce the amount of unsaponifiable fats. Then, the soap is dissolved in pure water for 48 hours to precipitate the impurities

- **The Cold method :** This is a simpler and faster.

method usually limited to the first stage only. The fat is heated to a temperature between 40 and 50 degrees Celsius, then the soda solution is gradually added while stirring continuously until the efflorescence appears. Then, the additives (colors, fragrances, plant extracts, etc.) are poured and mixed. The mixture is poured into molds immediately after mixing with the additives, the molds are covered, and left to complete the saponification process for 48 hours. The soap is then removed from the molds and left for one to three weeks to adjust its pH. Dunn, K. (2010)

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Part Tow : Materials and Methods

Chapter One :

Planat Material

I. Materials and methods:

- The extraction process and the qualitative phytochemical screening of the secondary metabolites of the studied plant were carried out in the pedagogical laboratories of the Department of Chemistry, Faculty of Mathematics and Material Sciences

1. Chemicals:

- The following chemicals were used in this study

Chemicals	Chemical Formula	Role
Ethanol	C ₂ H ₅ OH	extraction solvent
Distilled water	H ₂ O	Solvent and reagent preparation
Aluminum chloride	AlCl ₃	Flavonoid detection reagent
Hydrochloric acid	HCl	Acidifying reagent used to confirm flavonoids
Sodium hydroxide	NaOH	Coumarin detection reagent (Alkaline Reagent Test)
Ferric chloride	FeCl ₃	Tannin detection reagent (Ferric Chloride Test)
Iodine ,Potassium iodide	I ₂ , KI	Reagent for alkaloid detection(wanger's reagent)
Acetic acid	C ₄ H ₆ O ₃	Reagent in Liebermann–Burchard test for steroids
Sulfuric acid	H ₂ SO ₄	Reagent in Liebermann–Burchard and Salkowski tests
Chloroform	CHCl ₃	Reagent for steroids and terpenoids detection

2. Equipment:

Equipment	Function
Ultrasonic bath	Assists extraction process
Rotary evaporator	Solvent removal
UV spectrometer	Absorbance measurement
pH paper	pH measurement
Analytical balance	Accurate weighing
Glassware (beakers, flasks, pipettes)	Laboratory use
Test tubes	Conducting tests

II. Sample collection (*Anabasis Articulata*) :

The plant material used in this study was collected in February from El Aanat area, Touggourt Province, Algeria, located approximately at the geographical coordinates 33°12' N latitude and 6°03' E longitude. After collection, the plant samples were thoroughly washed with running water to remove adhering soil and impurities. They were then left to dry at room temperature in a dry, shaded, and well-ventilated place in order to preserve their bioactive compounds and prevent degradation caused by heat or direct sunlight. Once completely dried, the aerial parts of the plant (stems and leaves) were separated and selected for further use in the study, prior to the subsequent processes of grinding and extraction.

III. Preparation of the Extract: "The extraction process was carried out in the pedagogical laboratories of the Department of Chemistry, Faculty of Mathematics and Material Sciences".

Extraction was performed using 1L of (w\w) (30\70) (v\w) solvent. The powdered plant material was subjected to ultrasound-assisted extraction (UAE) using an ultrasonic bath for 45 minutes at a controlled temperature ranging between 27–30°C in order to enhance the release of bioactive compounds. The obtained mixture was then filtered to remove solid residues.



Figure 8 : Extraction mixture during ultrasonic-assisted extraction



Figure 9 : Ultrasonic bath used for the extraction of bioactive compounds

IV. Concentration and Purification:

The filtrate was concentrated using a rotary evaporator under reduced pressure to obtain a crude concentrated extract. The crude extract was then reconstituted using recovered methanol at a ratio of 1:2 (extract:solvent) to improve compound dissolution and fractionation. Subsequently, the solution was centrifuged to remove insoluble impurities and obtain a clearer fraction. The supernatant was evaporated again under reduced pressure to remove residual solvent, yielding a purified concentrated extract. Finally, the extract was stored in airtight containers at 4°C until further use.



Figure 10 : Concentration of the crude extract using a rotary evaporator under reduced pressure



Figure 11 : The plant extract during the solvent evaporation process

- ✓ The main stages involved in the extraction of the crude plant extract and its purification from impurities are illustrated in the following flowchart

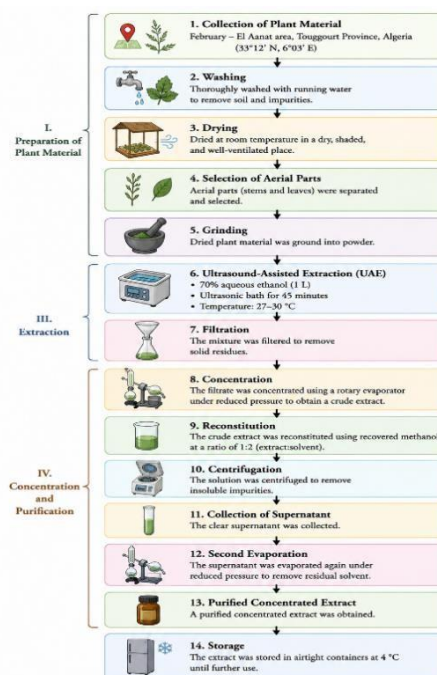


Figure 12 :Extraction and Purification Flowchart of the Plant Extract

V. Phytochemical Screening:

- Preliminary Chemical Screening of Secondary Metabolites: Preliminary

phytochemical screening was carried out in order to identify the major classes of secondary metabolites present in the plant extract. This qualitative analysis was performed using standard chemical tests based on specific colour reactions and precipitation methods. Different reagents were used to detect the presence of various bioactive compounds such as alkaloids, flavonoids, tannins, saponins, terpenoids, phenolic compounds. The appearance of characteristic colours or precipitates indicated the presence of the corresponding phytochemical groups. These screening tests provide important preliminary information about the chemical composition of the plant and its potential biological activities.

1. Flavonoids:

Flavonoids were qualitatively detected using the aluminum chloride test. A portion of the plant extract was treated with 10% AlCl_3 solution followed by the addition of NaOH. Tiwari et al. (2011)

- The development of a yellow coloration, which faded after the addition of HCl, indicated the presence of flavonoids. (Harborne, 1998).

2. Phenol:

Preliminary detection of phenolic compounds was carried out using the ferric chloride test, Approximately 0.5 g of the powdered plant material was mixed with 10 mL of distilled water and heated to boiling, followed by filtration. Subsequently, a few drops of 0.1% FeCl_3 solution were added to the filtrate. Sasidharan et al. (2011)

- The appearance of a dark blue-black coloration was considered indicative of the presence of phenolic compounds.

3. Alkaloids:

Wagner's reagent is a qualitative chemical reagent used for the detection of alkaloids. It is prepared by dissolving 0.127 g of iodine (I_2) and 0.20 g of potassium iodide (KI) in distilled water, and the final volume is adjusted to 10 mL. Tiwari et al. (2011)

- When a few drops of Wagner's reagent are added to a plant extract containing alkaloids, a positive reaction is indicated by the appearance of a brown to reddish-brown precipitate, confirming the presence of alkaloids in the tested sample.

4. Coumarins:

The qualitative detection of coumarins was performed by adding 3 mL of a 10% sodium hydroxide (Sodium Hydroxide) solution to 2 mL of the aqueous extract in a test tube. Yadav & Agarwala (2011)

- The appearance of a yellow coloration indicates the presence of coumarins in the plant sample.

5. Steroids:

A 0.5 g portion of the plant material is subjected to maceration, followed by the addition of 1 mL of acetic anhydride ($C_4H_6O_3$). The mixture is homogenized, allowed to stand for a short period, and then filtered to obtain the extract. The filtrate is subsequently treated with 10 mL of chloroform ($CHCl_3$), after which concentrated sulfuric acid (H_2SO_4) is carefully added along the wall of the test tube. Sasidharan et al. (2011)

- The appearance of a bluish-green coloration at the interface indicates a positive reaction.

6. Tannins:

Tannins were detected using the ferric chloride test according to the method described by Jeffrey B. Harborne. Briefly, 1 g of the powdered plant material was boiled in 20 mL of distilled water for 5 minutes, and the mixture was then filtered to obtain the filtrate. Subsequently, a few drops of 0.1% ferric chloride ($FeCl_3$) solution were added to the filtrate. This test is based on the formation of colored complexes between ferric ions and phenolic compounds present in tannins. Dai & Mumper (2010)

- The appearance of a blue-black or dark green coloration indicates the presence of tannins in the tested plant sample.

7. Terpenes:

5 mL of the plant extract is taken in a test tube, followed by the addition of 2 mL of chloroform ($CHCl_3$). The mixture is shaken well. Then, 3 mL of concentrated sulfuric acid (H_2SO_4) is carefully added along the side of the test tube to form two separate layers. Tiwari et al. (2011); Sasidharan et al. (2011)

- The appearance of a reddish-brown layer at the interface indicates the presence of terpenoids.

Chapter Tow

Total Phenolic Content and Biological Activities of the Plant Extract

The
quantitative determination of phenolic compounds(TPC)

I. Estimation of Total Phenolic Content (TPC) Using the

Folin–Ciocalteu Method: (Asia belfar.2018)

The assay was carried out in the Date Palm Laboratory at the Agricultural Research Center of the National Institute of Agronomic Research of Algeria (INRAA).

1. Materials and Methods:

➤ Equipment and chemicals used:

The device	Type
• UV-Vis spectrophotometer	JENWAY 6305
• Analytical Balance	Adam Equipment Nimbus NBL 214i

➤ Chemicals :

- Chemicals used in the quantitative analysis of phenolic compounds.

Chemicals	Purity
Plant extract	Curde
Gallic Acid ((OH) $3C_6H_2COOH, H_2O$)	98%
Sodium carbonate (Na_2CO_3)	99%
Distilled water	Distilled
Folin- Ciocalteu reagent ($C_{10}H_5NaO_5S$)	commercial reagent

➤ Laboratory Glassware:

Material	
Beaker 100 ml	1
Erlenmeyer Flask 100 ml	4
Graduated Cylinder 100 ml	1
Pipette 5 ml	1
Tubs 5ml	10
Tubs 10 ml	10
Reagent bottle	3
Whatman filter paper	8

➤ **Extraction yield calculation:**

- The plant extract obtained from the previously described extraction process was used as a crude sample to perform the quantitative analysis of total phenolic compounds, in order to determine the overall concentration of these biologically active compounds in the studied plant.
- The extraction yield was calculated using the following equation:

$$R\% = \frac{m}{m_0} \times 100$$

➤ **Determination of total phenolic compounds (TPC):**

The total phenolic content in the plant extracts was quantitatively determined using the Folin–Ciocalteu reagent method. This reagent is based on the reaction of phenolic compounds with a mixture of phosphomolybdic acid ($\text{H}_3\text{PMo}_{12}\text{O}_{40}$) and phosphotungstic acid ($\text{H}_3\text{PW}_{12}\text{O}_{40}$). The reduction of these complexes by phenolic compounds leads to the formation of blue-colored molybdenum and tungsten oxide complexes. The intensity of the developed blue color is directly proportional to the concentration of phenolic compounds present in the sample.

- **Preparation of standard solutions:**

- ✓ A stock solution of gallic acid was prepared at a concentration of 0.3 mg/mL, from which a series of standard solutions ranging from 0.03 to 0.3 mg/mL was obtained by serial dilution.



Figure 13 : Preparation of gallic acid standard solutions by serial dilution

- ✓ A 10% folin-Ciocalteu solution was prepared by dissolving 5 ml of folin in 50 ml of distilled water.
- ✓ To prepare a 6% Na_2CO_3 solution, 6 g was dissolved in 100 ml of distilled water.

for the preparation of a 6% solution.

- The assay was performed by mixing 0.5 mL of the standard solution (Acid Galic) with 0.5 mL of diluted Folin–Ciocalteu reagent (10%). After 5 min, 2.5 mL of sodium carbonate solution (Na_2CO_3 , 6%) was added. The reaction mixture was thoroughly mixed and incubated in the dark at room temperature for 30 min. The absorbance was measured at 765 nm using a UV–Visible spectrophotometer against a blank solution.

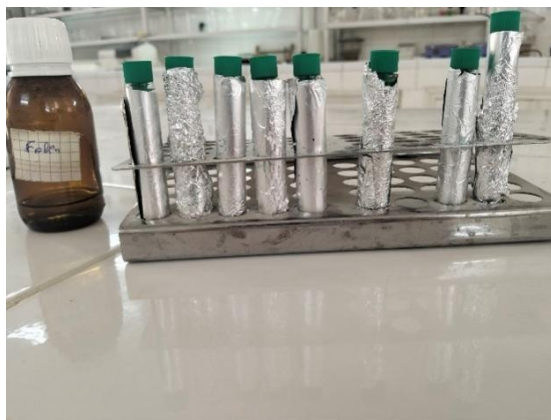


Figure 14 : Preparation of test tubes for the Folin–Ciocalteu assay

- The plant extract was analyzed under the same experimental conditions as the gallic acid calibration standards. Briefly, 0.5 mL of the extract was used for each assay. Three independent replicates were performed for the same sample to ensure reproducibility of the results. A blank sample was prepared by replacing the plant extract with distilled water, since all dilutions were carried out using water. The blank was used to zero the spectrophotometer prior to absorbance measurements.
- The total phenolic content of the extracts was determined using gallic acid as a standard reference, and the results were expressed as milligrams of gallic acid equivalents per gram of extract (mg GAE/g extract). The determination was based on the Beer–Lambert law, which correlates absorbance with concentration according to the following equation:

$$A = kC + b$$

- where:
 - A: absorbance measured at 725 nm.
 - C: concentration of the sample (g/L).
- After considering the dilution factor and the volume of the sample used, the total phenolic content was calculated using the following equation:

$$C(\text{mg/g}) = ((A \times N_A \times V) / (m \times k)) 100$$

- where:
- C: total phenolic content (mg/g).
- N_d: dilution factor.
- V: volume of the liquid extract used in the analysis (mL).
- m: mass of the plant material or sample used for extraction (g).
- k: slope of the gallic acid standard curve.

II. **Protein Denaturation Using Egg Albumin** : Chandra, S. et al. (2015).

1. Materials and Methods:

➤ Equipment and chemicals used:

The device	Type
• UV-Vis spectrophotometer	JENWAY 6305
• Analytical Balance	Adam Equipment Nimbus NBL 214i

➤ Chemicals :

- ✓ Distilled water was used instead of phosphate buffer solution because the latter was not available during the experiment.

Chemical	Function in the Assay
Egg Albumin	Protein used to simulate protein denaturation during inflammation
Distilled Water	Used as the reaction medium and for the preparation of solutions and dilutions
Plant extract , Soap ,Cream	Test sample evaluated for its anti-inflammatory activity

2. Laboratory Glassware:

Material	Quantity
Beaker 100 ml	3
Erlenmeyer Flask 100 ml	2
Graduated Cylinder 100 ml	1
Pipette 5 ml	1

Tubs 5ml	10
Tubs 10 ml	10
Reagent bottle	1

3. Protein Denaturation (Egg Albumin Method):

The anti-inflammatory activity of the ethanolic extract of *Anabasis articulata* was evaluated using the inhibition of egg albumin denaturation method with slight modifications. The assay was carried out in the Date Palm Laboratory at the Agricultural Research Center of the National Institute of Agronomic Research of Algeria (INRAA).

➤ **Preparation of albumin solutions:**

- ✓ A 5% (v/v) egg albumin solution was prepared by mixing:
- ✓ 5 mL of fresh egg white
- ✓ 95 mL of distilled water

The mixture was homogenized thoroughly before use.

- A stock solution of the ethanolic extract was prepared at a concentration of: 1000 µg/mL

From this stock solution, three concentrations were prepared:

- ✓ 0.1 mg/mL
 - ✓ 0.2 mg/mL
 - ✓ 0.4 mg/mL
 - ✓ 0.6 mg/mL
 - ✓ 0.8 mg/mL
- The solutions of the formulated products (cream and soap) were prepared by dissolving 1 g of each formulation in 10 mL of distilled water under continuous stirring to ensure complete homogeneity. The prepared solutions were then used directly in the egg albumin denaturation assay to evaluate their anti-inflammatory activity.

2) Preparation of reaction mixture:

- For each concentration, the reaction mixture was prepared in test tubes as follows:

Component	Volume
Distilled water (buffer medium)	2.8 Ml
Egg albumin (5%)	0.2 mL
Plant extract	2 mL

- A control tube was prepared using distilled water instead of the plant extract.
- Prior to conducting the main anti-inflammatory assay, a preliminary trial was performed to standardize the experimental procedure and evaluate the visual changes associated with protein denaturation. The experiment aimed to confirm the suitability of the prepared solutions, assess the reaction behavior, and facilitate the qualitative observation of turbidity or coagulation changes indicative of protein denaturation inhibition



Figure 15 : Sample tubes during incubation at 70°C

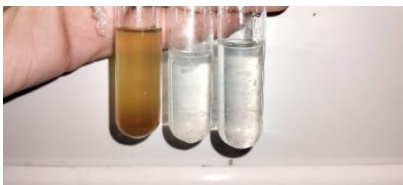


Figure 16 : Sample tubes after incubation

Where :

- 1: control
- 2:albumin with
- 3:albumin with extract

- ✓ Following the preliminary trial, the main anti-inflammatory assay was carried out using the egg albumin denaturation method. Five different concentrations of the plant extract were evaluated to investigate the concentration-dependent inhibitory effect on protein denaturation. In addition, the formulated anti-inflammatory cream and soap containing the plant extract were tested and compared with their respective blank formulations (without extract). This experiment aimed to assess the anti-inflammatory potential of the extract and the developed topical formulations through their ability to inhibit heat-induced protein denaturation.

3) Incubation:

- ✓ The mixtures were first incubated at room temperature for 15 min, followed by heating in a water bath at: 70°C for 10 min.
- ✓ After cooling, the absorbance was measured spectrophotometrically at 650 nm.
- ✓ Because the extract exhibited a noticeable coloration, a blank was prepared for each concentration by replacing egg albumin with distilled water in order to eliminate the interference caused by the intrinsic color of the extract.
- ✓ **Calculation of inhibition percentage:**

- ✓ The absorbance values of blanks were subtracted from the corresponding sample absorbances to obtain corrected absorbance values.

$$A_{corrected} = A_{sample} - A_{blank}$$

- A_{Sample} : The absorbance of the sample containing the extract + albumin.
 - A_{Blank} : The absorbance of the blank sample containing the extract without albumin (or with distilled water instead of albumin).
 - $A_{Corrected}$: The corrected absorbance after removing the effect of the extract's own colour.
- ✓ The percentage inhibition of protein denaturation was calculated according to the following equation:

$$I = \frac{A_C - A_E}{A_C} \times 100$$

- A_C : absorbance of the control
- A_S : corrected absorbance of the sample

III. DPPH Radical Scavenging Assay:

1. Materials and Methods:

1) Equipment and chemicals used:

The device	Type
• UV-Vis spectrophotometer	JENWAY 6305
• Analytical Balance	Adam Equipment Nimbus NBL 214i

2) Chemicals :

- Chemicals used in the quantitative analysis of phenolic compounds.

Chemicals	Purity
DPPH (2,2-diphenyl-1-picrylhydrazyl)	95%
Ehanol	96 %
Plant Extract	Curde

3) Laboratory Glassware:

Material	Quantity
Beaker 100 ml	1
Erlenmeyer Flask 100 ml	1

Graduated Cylinder 100 ml	1
Pipette 5 ml	1
Tubs 5ml	5
Tubs 10 ml	5
Reagent bottle	1
Aluminium foil	1

4) Preparation of solutions:

- ✓ The preparation of a DPPH solution at a concentration of 0.1 mM and a final volume of 100 mL was calculated using the following equation:

$$m = C \times V \times M$$

Where:

- m: mass in grams (g)
- C: molar concentration (mol/L)
- V: volume in liters (L)
- M: molar mass of DPPH (394.32 g/mol)

Substituting the values:

- $C = 0.1 \text{ mM} = 0.0001 \text{ mol/L}$
- $V = 100 \text{ mL}$

Therefore:

- $m = 0.0001 \times 0.1 \times 394.32$
- $m = 0.0039432 \text{ g} \rightarrow m \approx 3.94 \text{ mg}$

- ✓ Thus, approximately 3.94 mg of DPPH was weighed, dissolved in ethanol and the final volume was adjusted to 100 mL.



Figure 17 : Weighing DPPH for the preparation of the DPPH Solution

- A stock solution of the plant extract was prepared in ethanol by dissolving 1 g of the crude extract in 100 mL of ethanol, resulting in a concentration of 10 mg/mL.
 - 0.01 mg/mL
 - 0.02 mg/mL
 - 0.03 mg/mL
 - 0.04 mg/mL
 - 0.05 mg/mL
- For the DPPH assay, 2 mL of DPPH solution was mixed with 2 mL of each sample concentration in test tubes. The mixtures were incubated in the dark for 30 minutes at room temperature to allow the reaction to proceed. The absorbance was then recorded using a UV-Visible spectrophotometer at the appropriate wavelength

IV. Antibacterial test: " The antibacterial activity assay was conducted in the Biology Laboratory of the Mother and Child Hospital (Maternity), Touggourt, Algeria.

The antibacterial activity was evaluated using the disk diffusion method on Mueller–Hinton agar (MHA) according to standard procedures described in the literature, where sterile paper discs impregnated with plant extract are placed on inoculated agar plates and incubated at 37°C for 18–24 h to determine the zone of inhibition

- The antibacterial activity test is a method used to evaluate the ability of the plant extract and the prepared products derived from it (cream and soap) to inhibit bacterial growth. This assay is based on the disc diffusion technique on Mueller–Hinton agar medium, where inhibition zones are measured after incubation to determine the antibacterial effectiveness against different bacterial strains.

1. Preparation of Culture Medium:

- ✓ The antibacterial activity was evaluated using the disk diffusion method on Mueller–Hinton agar (MHA). The culture medium was prepared according to the manufacturer's instructions and heated in a water bath at 100°C until complete dissolution. The molten medium was then poured aseptically into sterile Petri dishes and allowed to solidify at room temperature.



Figure 18: Preparation of Mueller–Hinton agar plates used for the antibacterial activity assay

Culture and incubation of bacterial strains:

Three bacterial strains were used in this study *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. Fresh bacterial cultures were inoculated onto the surface of the Mueller–Hinton agar plates using sterile swabs to obtain a uniform bacterial lawn. The inoculated plates were left for a few minutes to allow absorption of the inoculum before applying the test samples. Subsequently, the plates were incubated at 37°C for 24 hours.



Figure 19: Bacterial cultures after 24 hours of incubation

3. Disc Loading with Samples:

- Fresh bacterial colonies from each tested strain were suspended in sterile saline solution, and the turbidity was adjusted to match the 0.5 McFarland standard (approximately 1.5×10^8 CFU/mL). The standardized bacterial suspensions were then spread uniformly over the surface of fresh Mueller–Hinton agar plates using sterile cotton swabs.
- Sterile paper discs impregnated with the tested samples were placed on the inoculated agar surface. The tested samples included the plant extract, its different dilutions, the cream containing the extract, and the cream base without extract as a negative control. The plates were incubated at 37°C for 24 hours. After incubation, the antibacterial activity was assessed by measuring the diameter of the inhibition zones (mm) formed around the discs.



Figure 20 : Mueller–Hinton agar plates inoculated with bacterial strains before incubation

Chapter three

Manufacture of Soap and anti-inflammatory cream

❖ Soap :

I. Materials :

1. Oil phase

- olive oil
- Sweet almond oil
- Beeswax

2. Aqueous phase:

- Distilled water
- Sodium hydroxide (NaOH) as a alkalin agent

3. Active ingredient:

- Anabasis articulata plant extract (locally used name; commonly associated with Anabasis articulata)
- Vitamin E

II. Soap Formulation Design:

✓ Example formulation (100 g total oils)

Ingredient	Percentage (%)	Mass (g)
Coconut oil	40%	90 g
Sweet almond oil	18%	15 g
Olive oil	35%	80g
Beeswax	7%	15 g

✓ Calculation of NaOH Amount (SAP Method)

The required NaOH was calculated using the saponification value (SAP) of each fat:

1. SAP values (NaOH equivalent):

- Coconut oil = 0.183
- Sweet almond oil = 0.136
- Olive oil = 0.134
- Beeswax = 0.067

2. Formula:

$$\text{NaOH (g)} = \sum (\text{Oil mass} \times \text{SAP value}) \times (1 - \text{superfat fraction})$$

Superfat level was set at 5% (0.05) to improve skin mildness.

3. Calculation for 100 g oils

Coconut oil: $90 \times 0.183 = 16.47$

Almond oil: $40 \times 0.136 = 5.44$

Olive oil: $80 \times 0.134 = 10.72$

Beswax: $15 \times 0.067 = 1.005$

Total NaOH = 33.635 g

Applying 5% superfat:

NaOH required = $33.635 \times 0.95 = 31.953$ g NaOH (approx.)

4. Preparation of Lye Solution:

Sodium hydroxide was slowly dissolved in distilled water under continuous stirring. The solution was left to cool to 40–50°C before use.



Figure 21 : Weighing NaOH to prepare an alkaline solution

5. Oil Phase Preparation:

All solid fats (Coconut oil and beeswax) were melted at 70°C, then mixed with coconut oil and sweet almond oil. The mixture was homogenized and cooled to 40–50°C.

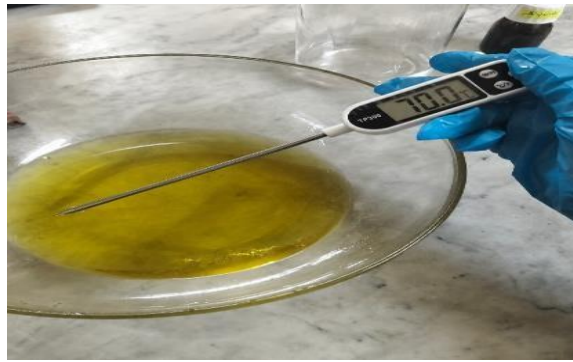


Figure 22 : (A) Weighing the solid fat (coconut oil)



Figure 23 : (B) Adding Bees wax



Figure 24 : (C) Adding sweet almond oil



Figure 25 : (D) Measuring the temperature of the oil mixture 70°

6. Saponification Process:

The NaOH solution was slowly added to the oil phase under continuous stirring until reaching the trace stage, indicating emulsification and early soap formation.



Figure 26 :: Saponification Process

7. Addition of Active Ingredients :

- Anabasis articulata extract was added at 2% (w/w)



Figure 27 : Addition of Anbasis articulata plant extract

- Gentle mixing was applied to preserve phytochemical integrity.

8. Molding and Curing

The mixture was poured into molds and left for 24–48 hours at room temperature. After demolding, soaps were cured for 4–6 weeks in a dry, ventilated environment to complete saponification and reduce alkalinity.

❖ Anti-inflammatory Cream

1 Oily Phase:

Ingredient	Mass (g)
Sweet almond oil	5 g
Coconut oil	3g
Glycerine	5g

Heat in a water bath at 75°C until completely melted.

2 Aqueous Phase:

Heat 100 g Distilled water to 75°C

Add:

- 0.8 g cosgard
- 5 g Lannette N

Stir until dissolved.

3 Emulsification:

1. Add aqueous phase slowly to oily phase under continuous stirring until cooling and cream formation. pH Adjustment
2. Leave to cool, then add the extract and the vitamin E

❖ Physical evaluation of soap and cream:

I. Soap :

1. pH determination (target: 8–10)

A small quantity of the cream was dissolved in distilled water to obtain a homogeneous dispersion. The pH of the prepared sample was then determined using pH indicator paper by comparing the developed color with the standard pH scale.

2. Hardness test:

The hardness of the prepared sample was evaluated by applying gentle pressure with a finger and observing its resistance to deformation. The consistency and firmness of the sample were then recorded.

3. Stability studies :

The prepared cream was subjected to stability studies at three different storage conditions: 4°C (refrigerated temperature), room temperature ($25 \pm 2^\circ\text{C}$), and $40 \pm 2^\circ\text{C}$. Samples were stored under these conditions for a

specified period and periodically evaluated for changes in physical appearance, color, odor, homogeneity, phase separation, and pH

4. Organoleptic properties (Color ,Odor,Texture,Foam quality)

II. Anti inflammatory cream : (Arushi & Choudhary, 2024)

1. pH Determination:
 - Dissolve a small quantity of cream in distilled water.
 - Measure pH using pH paper .
 - Acceptable range: 4.5–6.5.
2. Homogeneity Test: Examine cream visually for:
 - uniform appearance
 - absence of lumps
 - smooth texture
3. Spreadability Test:
 - Place a small amount of cream between two glass slides.
 - Apply a standard weight.
 - Measure spread diameter.
4. Washability Test:
 - Apply cream on skin and assess ease of removal with water
5. Viscosity Test:
 - evaluate consistency manually (thick / medium / light).
6. Stability Study
 - Store cream samples at: Room temperature ,4°C ,40°C for 2–4 weeks.
 - Observe: color change ,odor ,phase separation ,texture

Chapter three

Results and Discussion

I. Phytochemical Screening:

1. **Flavonoids :** A distinct yellow coloration was observed after treatment with AlCl_3 and NaOH , which faded considerably following the addition of dilute HCl , confirming the presence of flavonoids in the tested extract.



Figure 28 : .(A) Yellow coloration after addition of AlCl_3 and NaOH .



Figure 29 : (B) Fading of the yellow color after addition of dilute HCl

•Discussion:

The qualitative screening confirmed the presence of flavonoids in the ethanolic extract of *Anabasis articulata*, as indicated by the development of a yellow coloration that markedly faded after the addition of dilute HCl . This finding is consistent with previous studies, which reported the presence of flavonoids and other phenolic compounds in *A. articulata* (Benslama et al., 2022). Flavonoids are known for their antioxidant and anti-

inflammatory activities and may contribute significantly to the pharmacological properties of this plant (Panche et al., 2016).

2. **Phenols:** The Ferric chloride (FeCl_3) test showed a strong dark coloration, which is a qualitative indication of a considerable presence of phenolic compounds in the extract.



Figure 30 : Qualitative detection of Phenols in *Anabasis articulata*

•Discussion:

This result reflects the high richness of the extract in phenolic compounds, which are among the most powerful natural antioxidants. Phenolics are known for their ability to donate electrons and neutralize free radicals, thereby reducing oxidative damage to cells (Dai & Mumper, 2020). They also contribute to the inhibition of oxidative enzymes and the reduction of inflammatory processes (Shahidi & Yeo, 2021).

3. **Alkaloids:** Wagner's test gave a positive result, characterized by turbidity and a brownish-red coloration, with a more pronounced reaction in the ethanolic extract compared to the aqueous one.



Figure 31 : Qualitative detection of Alkaloids in *Anabasis articulata* extract by the Wagner's test

•Discussion:

The presence of alkaloids indicates that the plant contains nitrogen-containing compounds with significant biological activity. Alkaloids are well known for their antimicrobial properties as well as a wide range of physiological effects (Kumar & Singh, 2021). The difference in reaction intensity between extracts can be explained by differences in solubility and extraction efficiency of these compounds.

4. **Coumarins:** The addition of sodium hydroxide (NaOH) solution to the extract resulted in the appearance of a characteristic yellow coloration, which is a qualitative reaction indicating the presence of coumarins in the studied plant.



Figure 32 : Qualitative detection of Steroids in Anabasis articulata

•Discussion:

Coumarins are lactonic phenolic compounds widely distributed in medicinal plants and are characterized by a chemical structure that enables them to exhibit various biological activities (Borges et al., 2020). The color change observed under alkaline conditions is explained by the opening of the lactone ring and structural rearrangement of the molecule, which serves as a qualitative indicator for their presence (Borges et al., 2020).

From a biological perspective, coumarins possess anti-inflammatory properties through the inhibition of inflammatory mediators and the reduction of inflammatory responses (Borges et al., 2020; Lake, 2021). In addition, several studies have reported their anticoagulant and antioxidant activities, which further enhances their pharmacological importance (Lake, 2021).

5. Steroids:

The Liebermann–Burchard test produced a green coloration, which is a characteristic qualitative indication of the presence of steroidal compounds in the plant extract.

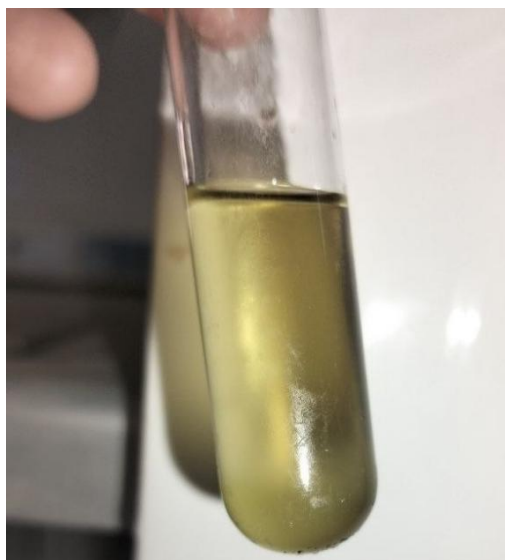


Figure 33 : Qualitative detection of Steroids in *Anabasis articulata* extract by the Liebermann–Burchard test

•Discussion:

This test is based on the reaction of steroidal compounds with strong acids and specific reagents, leading to the formation of characteristic color changes (Trease & Evans, 2009). Plant steroids are biologically important compounds due to their role in regulating inflammatory responses and influencing various cellular functions (Saleem, 2021).

Recent studies have shown that these compounds contribute to reducing inflammation by modulating cytokine production and inflammatory mediators (Saleem, 2021). They also play a role in stabilizing cell membranes, thereby protecting cells from harmful external factors (Saleem, 2021).

6. Tannins:

Tannins showed a positive reaction with ferric chloride salts, resulting in the formation of a dark coloration or a characteristic precipitate, indicating their presence in the extract.



Figure 34 : Qualitative detection of Tannins in *Anabasis articulata*

•Discussion:

Tannins are high-molecular-weight polyphenolic compounds with the ability to bind strongly to proteins and other biological macromolecules (Scalbert, 1991). The reaction with iron salts is explained by the formation of colored complexes due to the presence of free phenolic hydroxyl groups in their structure (Scalbert, 1991).

From a biological point of view, tannins exhibit antimicrobial activity by inhibiting the growth of bacteria and fungi, in addition to their antioxidant properties (Chung et al., 2021). They also contribute to reducing inflammation and protecting tissues due to their astringent properties (Scalbert, 1991; Chung et al., 2021).

7. Terpenoids :

The Salkowski test gave a positive result for terpenoids, as evidenced by the formation of a reddish-brown ring at the interface between the two layers, confirming the presence of terpenoid compounds in the extract



Figure 35 : Qualitative detection of terpenoids in *Anabasis articulata* extract by the Salkowski test

•Discussion:

The Salkowski test revealed a positive result for terpenoids in the *Anabasis articulata* extract, as indicated by the formation of a reddish-brown layer at the interface between the two phases. This observation confirms the presence of terpenoid compounds among the secondary metabolites of the plant. Terpenoids are recognized as one of the most important classes of bioactive phytochemicals and have been reported to possess a wide range of pharmacological activities, including antioxidant, anti-inflammatory, and antimicrobial properties (Al-Joufi et al., 2022). These biological effects are mainly attributed to their ability to neutralize reactive oxygen species and modulate inflammatory mediators (Al-Joufi et al., 2022).

The present finding is consistent with recent phytochemical investigations on *Anabasis articulata*, which reported the occurrence of terpenoid and triterpenoid constituents and highlighted their contribution to the plant's biological activities (Gamal et al., 2022; Alamri et al., 2024). Therefore, the presence of terpenoids in the studied extract may contribute to the antioxidant, anti-inflammatory, and antimicrobial activities observed in the current study.

II. Results of quantitative determination of phenolic compounds(TPC):

1)Extraction yield calculation:

- ✓ The extraction yield was determined after evaporating the solvent and obtaining a concentrated extract.

m0	Me	R%
145 g	32g	22%

2)Phenol test results:

- ✓ The phenolic assay was performed following the previously described procedures and measurements, and the following results were obtained.

•Absorbance of the Acid Galic :

Concentrates	New Concentrates	Abcerbence
0.03 mg\ml	0.01	0.146
0.06 mg\ml	0.02	0.268
0.09 mg\ml	0.03	0.373
0.12 mg\ml	0.04	0.491
0.18 mg\ml	0.05	0.618

•Absorbance of the extract:

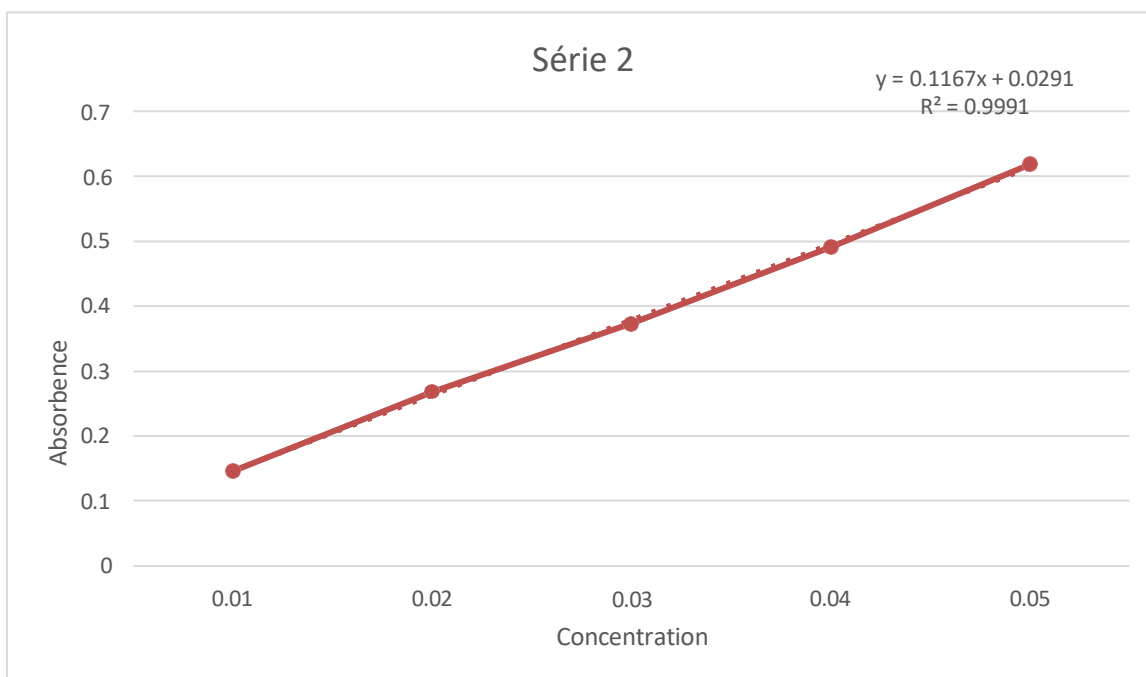
1.0.542

2.0.543

3.0.540

The mean absorbance value was 0.542

- ✓ Based on the obtained absorbance values, the standard calibration curve of gallic acid was established by plotting the absorbance at 765 nm (A) as a function of concentration C (g/L). The resulting curve exhibited a linear relationship represented by a first-degree equation , as illustrated in Figure



Curve01 :Gallic acid calibration curve

- The total phenolic content of the extract was determined after constructing the gallic acid standard calibration curve and was calculated according to the equation:
- The absorbance values obtained for gallic acid standard solutions were used to construct the calibration curve by plotting absorbance at 765 nm versus concentration. A linear relationship was observed, described by a first-degree equation. The absorbance of the plant extract was measured under the same experimental conditions, and the total phenolic content (TPC) was calculated from the gallic acid calibration curve using the corresponding dilution factors. The obtained value was:

•528.6±mg GAE/g extract

where GAE refers to gallic acid equivalents

•Discussion:

- The total phenolic content (TPC) of the ethanolic extract of *Anabasis articulata* was determined using the Folin–Ciocalteu method and expressed as gallic acid equivalents (GAE). The obtained value was 528.6 ± mg GAE/g extract, indicating a high richness of phenolic compounds in the studied extract. This elevated level reflects the efficiency of ethanol in extracting polar phytochemicals, particularly phenolic compounds known for their strong antioxidant and biological activities.
- The present results are consistent with those reported by Makhoul et al. (2013), who studied the ethanolic extract of *Anabasis articulata* and found a total phenolic content of approximately 310 mg GAE/g extract. Similarly, Boudjelal et al. (2015) reported lower values, ranging around 280–350 mg

GAE/g extract, depending on the extraction conditions and plant origin. These results confirm that *A. articulata* is a rich source of phenolic compounds, although the quantified amounts vary among studies.

- The observed differences in TPC values can mainly be attributed to variations in the extraction methodology. In the present study, ultrasound-assisted extraction (UAE) was employed, which is known to significantly enhance the release of phenolic compounds by disrupting plant cell walls and improving solvent penetration. In contrast, previous studies mostly used conventional extraction techniques such as maceration or Soxhlet extraction, which are generally less efficient and time-consuming. Therefore, the higher phenolic content obtained in this work may be explained by the improved extraction efficiency of ultrasound technology.
- Additionally, variations may also be influenced by environmental factors, geographical origin, harvesting period, and solvent polarity, all of which are known to affect the phytochemical composition of plant extracts.
- Overall, the relatively high TPC obtained in this study suggests that ultrasound-assisted ethanolic extraction of *Anabasis articulata* provides a more efficient method for recovering phenolic compounds, which may enhance its potential antioxidant and pharmacological applications.

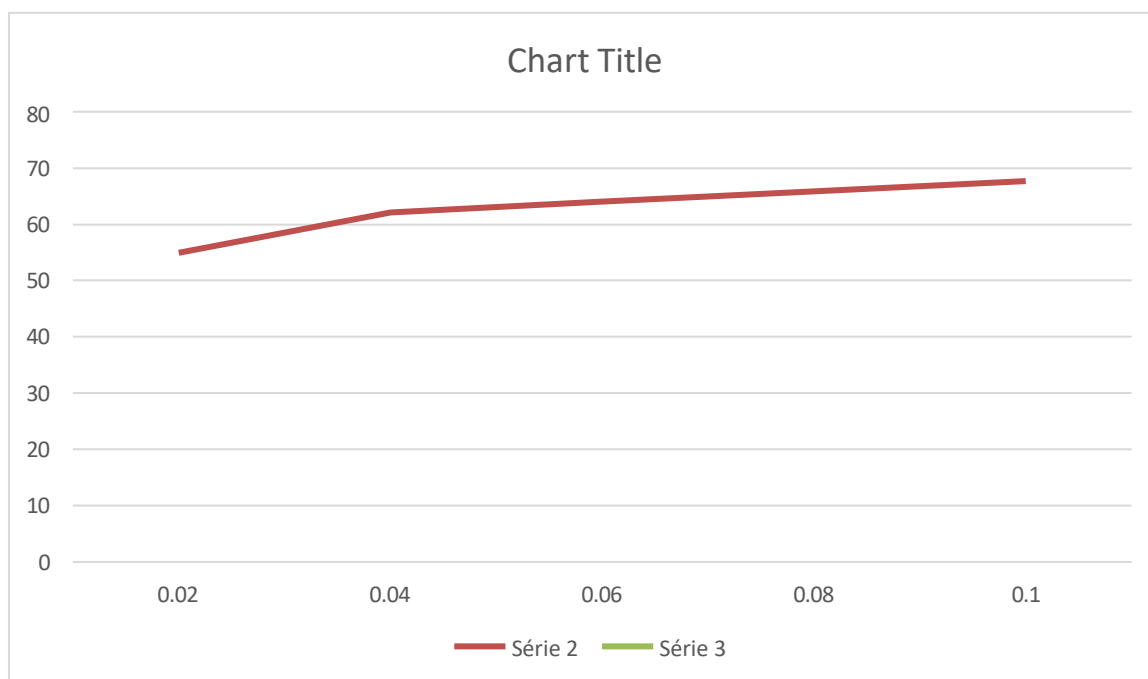
III. Results of Antioxidant Activity by DPPH Assay:

Results of Antioxidant Activity by DPPH Assay:

The antioxidant activity of the ethanolic extract was evaluated using the DPPH free radical scavenging assay. The extract exhibited a concentration-dependent antioxidant effect, as the percentage of DPPH inhibition increased with increasing extract concentration.

- DPPH Radical Scavenging Activity of *Anabasis articulata* Ethanolic Extract

Extract absorbance	Inhibition%
0.251	54.94%
0.211	62.12%
0.200	64.04%
0.190	65.89%
0.180	67.68%



- **Disscution:**

- The antioxidant activity observed in the ethanolic extract of *Anabasis articulata* may be attributed to the presence of phenolic compounds and flavonoids detected during phytochemical screening. These compounds are known for their ability to donate hydrogen atoms or electrons and neutralize free radicals, resulting in increased DPPH scavenging activity (Michalaki & Grintzalis, 2023; Rana et al., 2024).
- The concentration-dependent increase in DPPH inhibition observed in the present study is consistent with the mechanism described by Gülçin and Alwasel (2023), who reported that higher concentrations of antioxidant compounds enhance radical scavenging capacity

IV. Protein Denaturation Using Egg Albumin test results :

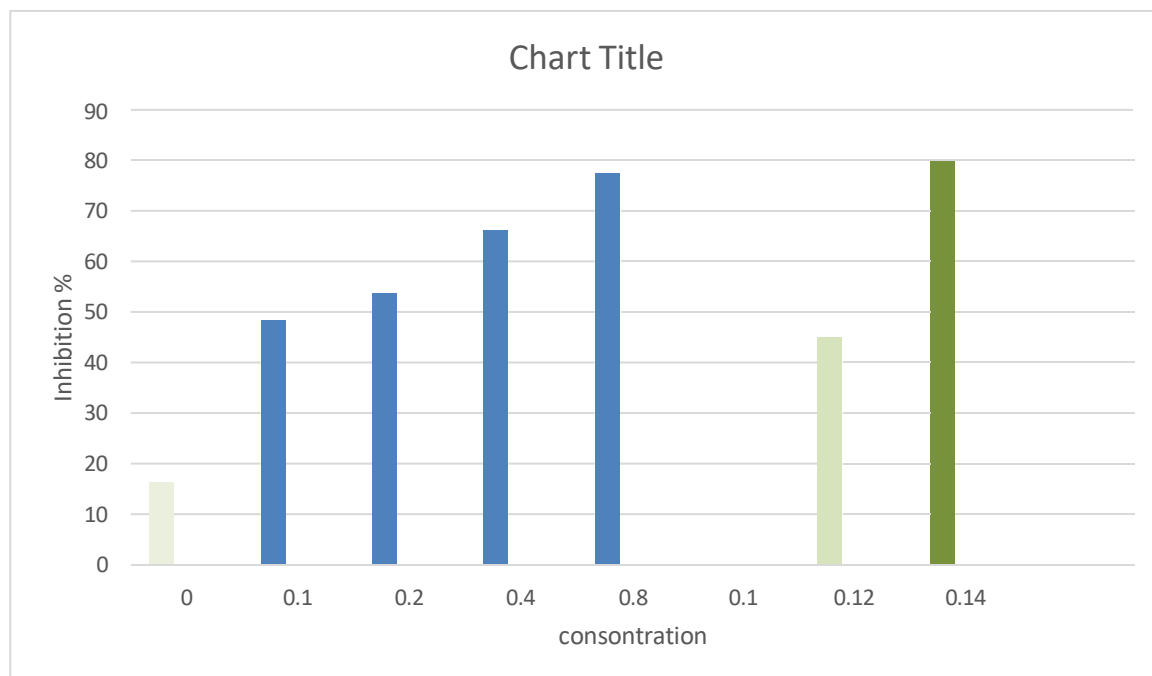
The anti-inflammatory potential of the ethanolic extract of *Anabasis articulata* was evaluated using the egg albumin denaturation method. The results demonstrated a clear concentration-dependent increase in the inhibition of protein denaturation.

- The percentage inhibition increased progressively with extract concentration, indicating enhanced stabilization of protein structure at higher dose
- Table 01. Inhibitory effect of *Anabasis articulata* ethanolic extract on protein denaturation

Concentration (mg/mL)	Absorbance	Absorbance of extract without albomin	Inhibition%
0.1	0.052	0.006	48.3 %
0.2	0.057	0.008	53.75%
0.4	0.042	0.020	66.25%
0.6	0.026	0.020	77.50 %
0.8	0.021	0.022	98.87%
00(Cream base)	0.0844	0.010	16.40%
0.12(Cream with extract)	0.0550	0.006	44.94 %
0.14(Soap)	0.0267	0.008	78.98%

- The results demonstrate that the highest inhibition was observed at 800 µg/mL, indicating strong anti-inflammatory activity of the extract.
- The results obtained from the egg albumin denaturation assay demonstrated a marked concentration-dependent anti-inflammatory activity of the ethanolic extract of *Anabasis articulata*. The percentage inhibition increased progressively with increasing extract concentration, reaching 98.87% at 800 µg/mL, indicating a strong ability of the extract to stabilize proteins against thermal denaturation. This effect may be attributed to the presence of bioactive phytochemicals, particularly phenolic compounds and flavonoids, which are known to interact with proteins and prevent structural alterations associated with inflammatory processes. These findings are consistent with previous studies on *Anabasis articulata*. Indeed, Ben Mennia et al. (2024) reported significant anti-inflammatory activity of a phenolic-rich extract of *A. articulata* and associated this effect with its high content of phenolic constituents. Likewise, Belyagoubi-Benhammou et al. (2013) demonstrated that the species possesses considerable antioxidant potential due to its richness in phenolic compounds, which may contribute indirectly to reducing inflammation through the inhibition of oxidative stress. Furthermore, the results agree with those reported by Makhoulouf, who

highlighted the abundance of bioactive secondary metabolites in *A. articulata* and their potential biological activities. The superior inhibitory effect observed for the extract-containing cream and soap compared with their respective bases further confirms that the active constituents remained stable after formulation and retained their biological efficacy. Therefore, the present findings support the potential use of *Anabasis articulata* as a promising natural source of anti-inflammatory agents for pharmaceutical and cosmetic applications.



Curve 3: Anti-inflammatory Activity of Plant Extract, Soap, and Cream Formulations

extract Cream base cream with extract soap

• Discussion:

- ✓ The egg albumin denaturation assay revealed that the ethanolic extract of *Anabasis articulata* exhibits a pronounced and concentration-dependent anti-inflammatory activity. The progressive increase in percentage inhibition with rising extract concentrations indicates a dose-responsive stabilization of protein conformation against thermal denaturation, a process widely recognized as a key in vitro model for inflammation-related protein damage. The highest inhibitory activity was recorded at 800 µg/mL (98.87%), suggesting a strong capacity of the extract to prevent protein aggregation and structural destabilization under stress conditions.
- ✓ This marked biological activity appears to be closely associated with the phenolic richness of the extract. The total phenolic content previously determined for the ethanolic extract of *A. articulata* was high (TPC = 528mg GAE/g extract)], indicating a substantial presence of redox-active secondary metabolites. A positive correlation can therefore be inferred between phenolic concentration and anti-inflammatory efficacy, as samples with higher phenolic levels systematically exhibited stronger inhibition of protein denaturation. This relationship is consistent with the well-established role of phenolic compounds as key

modulators of inflammatory processes through protein binding, enzyme modulation, and radical scavenging mechanisms.

- ✓ The observed bioactivity can be primarily attributed to the phytochemical richness of *A. articulata*, particularly its phenolic and flavonoid constituents. These secondary metabolites are known to interact with protein structures via hydrogen bonding and hydrophobic interactions, thereby enhancing protein stability and preventing conformational changes induced by thermal stress. In addition, their antioxidant properties may further contribute to the anti-inflammatory effect by mitigating oxidative stress, which is strongly implicated in protein denaturation and inflammatory mediator activation.
- ✓ The present findings are in strong agreement with Ben Mennia et al. (2024), who reported significant anti-inflammatory activity in phenolic-rich extracts of *A. articulata* and demonstrated that this effect was strongly correlated with total phenolic content. Likewise, Belyagoubi-Benhammou et al. (2013) highlighted the high antioxidant capacity of the species and emphasized the central role of phenolic compounds in reducing oxidative and inflammatory responses. Together, these studies support a direct link between phenolic abundance and anti-inflammatory potential in *A. articulata*.
- ✓ When compared with other medicinal plants from arid and semi-arid ecosystems, the ethanolic extract in the present study exhibited relatively higher inhibition values than those commonly reported for hydroalcoholic extracts under similar experimental conditions, where inhibition typically remains below 80% at comparable concentrations. This enhanced performance may be partially explained by the high phenolic yield achieved through ultrasound-assisted extraction, which improves solvent penetration and promotes efficient release of intracellular phenolic compounds.
- ✓ Furthermore, the formulated preparations (cream and soap) retained notable anti-inflammatory activity, albeit lower than that of the crude extract. The cream containing extract exhibited an inhibition of 44.94%, while the soap formulation showed a significantly higher activity of 78.98%, compared to 16.40% for the base cream. These results confirm that the bioactive compounds remain stable after formulation, although their effectiveness is influenced by the physicochemical environment of each matrix. The higher activity observed in the soap formulation may be associated with better dispersion and release of active constituents.
- ✓ Collectively, these results provide strong experimental evidence supporting the anti-inflammatory potential of *Anabasis articulata*. The data further confirm a clear positive relationship between total phenolic content and protein denaturation inhibition, highlighting phenolic compounds as major contributors to the observed biological activity. This reinforces the potential application of *A. articulata* as a promising natural source of anti-inflammatory agents for pharmaceutical and cosmetic development

V. Bacterial test results:

The antibacterial activity of the extract and the formulated cream containing *Anabasis articulata* extract was evaluated using the disc diffusion method against the tested bacterial strains. The antibacterial effect was determined by measuring the diameter of the inhibition zones formed around the impregnated discs after incubation for 24 h and 48h

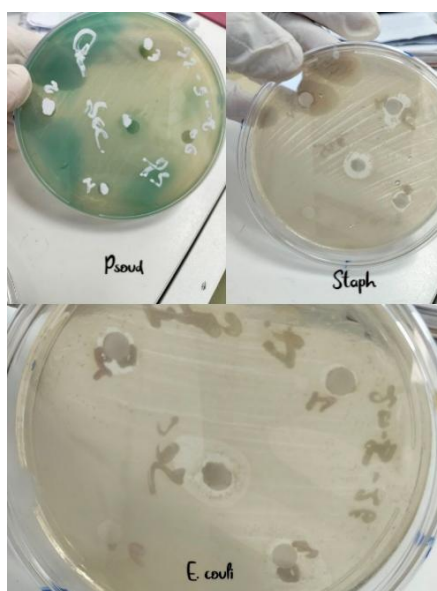


Figure 36: Antibacterial activity of the tested samples after 24 h of incubation

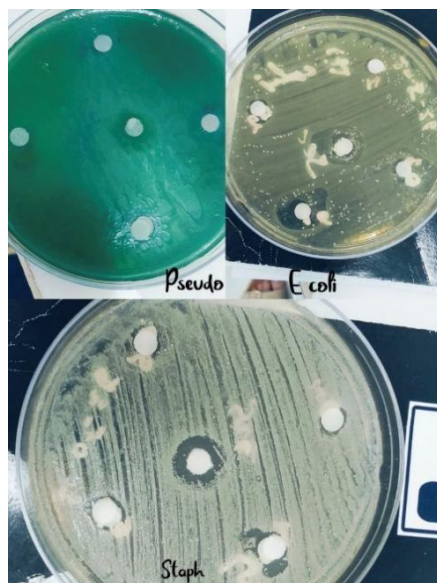


Figure 37: Antibacterial activity of the tested After 48h of incubation

✓ Results of inhibition zone diameters (mm):

The antibacterial activity of both the crude extract and the formulated cream containing *Anabasis articulata* extract was evaluated against three bacterial strains using the disc diffusion method. The diameters of the inhibition zones obtained are shown in the table

	Staphylococcus aureus 24h	Escherichia coli 24h	Pseudomonas aeruginosa 24h	Staphylococcus aureus 24h	Escherichia coli 24h	Pseudomonas aeruginosa 24h
10 mg/mL	12 mm	18mm	00mm	12mm	18mm	00mm
3.33 mg/mL	10mm	16mm	00mm	10mm	16mm	00mm
1.67 mg/mL	10mm	15mm	00mm	10mm	15mm	00mm
Cream base	9mm	7mm	00mm	9mm	7mm	00mm
Cream with extract	11mm	14mm	00mm	11mm	14mm	00mm

- ✓ The antibacterial activity of the ethanolic extract of *Anabasis articulata* and the formulated cream was evaluated using the disc diffusion method. The results showed concentration-dependent antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, while no inhibitory effect was observed against *Pseudomonas aeruginosa*. The inhibition zone diameters recorded after 48 h of incubation remained identical to those observed after 24 h, indicating the stability of the antibacterial effect and the absence of bacterial regrowth during prolonged incubation. The highest activity was observed at 10 mg/mL, producing inhibition zones of 12 mm and 18 mm against *S. aureus* and *E. coli*, respectively

● Discussion :

- ✓ The antibacterial activity of the ethanolic extract of *Anabasis articulata* and the formulated cream was evaluated against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* using the disc diffusion method. The results demonstrated a concentration-dependent inhibitory effect against *S. aureus* and *E. coli*, whereas no inhibitory activity was observed against *P. aeruginosa*. These findings indicate that the antibacterial efficacy of the extract is influenced by both the concentration of the extract and the susceptibility of the tested bacterial strain.
- ✓ The highest antibacterial activity was observed at a concentration of 10 mg/mL, producing inhibition zones of 12 mm against *S. aureus* and 18 mm against *E. coli*. The gradual decrease in inhibition zone diameters with decreasing extract concentration suggests that the antibacterial effect is dose-dependent. Similar findings were reported by Al-Joufi et al. (2022), who demonstrated that *Anabasis articulata*

extracts possess significant antibacterial activity attributed to their richness in bioactive phytochemicals, particularly phenolic compounds and flavonoids.

- ✓ The greater sensitivity of *E. coli* compared to *S. aureus* observed in the present study may be related to differences in bacterial physiology and the interaction of phytochemicals with bacterial cell structures. Phenolic compounds and flavonoids are known to exert antimicrobial effects through multiple mechanisms, including disruption of cell membrane integrity, alteration of membrane permeability, inhibition of essential enzymes, and interference with nucleic acid synthesis (Paval et al., 2023).
- ✓ No antibacterial activity was detected against *P. aeruginosa*. This result is not unexpected, as *P. aeruginosa* is recognized as one of the most resistant bacterial species due to its low outer membrane permeability, efficient efflux pump systems, and ability to form biofilms. These characteristics significantly reduce the susceptibility of the bacterium to many natural antimicrobial agents (Woo et al., 2023).
- ✓ The formulated cream containing *A. articulata* extract retained antibacterial activity against both *S. aureus* and *E. coli*, producing inhibition zones of 11 mm and 14 mm, respectively. This observation suggests that the formulation process did not adversely affect the biological activity of the extract and that the active constituents remained sufficiently available for diffusion through the agar medium. Consequently, the formulated cream may represent a promising topical preparation for the management of bacterial skin infections.
- ✓ The antibacterial activity observed in the present study may be associated with the phytochemical composition of *A. articulata*. Phytochemical screening revealed the presence of phenolic compounds and flavonoids, while quantitative analysis showed considerable levels of total phenolics and total flavonoids. Previous studies have demonstrated that these compounds possess strong antimicrobial properties and contribute significantly to the biological activities of medicinal plants (Al-Joufi et al., 2022; Ben Mennia et al., 2024).
- ✓ Furthermore, the antibacterial results are consistent with the antioxidant and anti-inflammatory activities obtained in the current investigation. The relatively high phenolic and flavonoid contents may explain the observed biological effects, as numerous studies have established a positive correlation between phenolic concentration and antimicrobial efficacy (Paval et al., 2023). These compounds are capable of damaging bacterial cell walls and membranes, causing leakage of intracellular constituents and inhibition of essential metabolic pathways.
- ✓ Interestingly, the inhibition zone diameters remained unchanged after 48 h of incubation compared with those recorded after 24 h. This observation indicates the stability of the antibacterial effect over time and the absence of significant bacterial regrowth within the inhibition zones. Such findings suggest that the active compounds present in the extract remained effective throughout the incubation period and maintained their inhibitory activity against susceptible bacterial strains.
- ✓ Overall, the results of this study confirm the antibacterial potential of *Anabasis articulata*, particularly against *S. aureus* and *E. coli*, and provide scientific support for its traditional use in the treatment of skin disorders. The successful incorporation of the extract into a topical cream while preserving its antibacterial activity further highlights its potential application in herbal dermatological formulations (Ben Mennia et al., 2024).

VI. Physical evaluation of soap and cream:

1. Soap :

- The prepared soap was subjected to a series of physicochemical, organoleptic, and stability evaluations to assess its quality, consistency, and suitability for cosmetic application

Test	Results
pH determination	8
Hardness test	• Hard and compact texture ,no deformation under normel pressure
Stability studies	• No change in color , odor or shape during storage
Organoleptic properties (Aspect , color,Texture ,Odor , Transparency , Inclusions)	• Solid , firm , with regular geometric edges • Natural dark beige to light brown • Smooth , dry , non-sticky • odor characteristic :mildly herbal (fragrance free) • opaque • Presence of fine botanical particles on the surface

2. Inflammatory cream:

- pH determination:



Figure 38: Determination of the pH of the prepared cream formulation using a universal pH indicator strip, showing a near-neutral pH (approximately 6–7)

- **Homogeneity Test:**

The prepared cream exhibited a smooth and uniform appearance without any visible lumps, coarse particles, or phase separation, indicating good homogeneity and proper dispersion of the ingredients within the formulation.

- **Washability Test:**

The prepared cream was easily washed off with water and did not leave any visible residue or greasy (oily) film on the skin surface, indicating good washability of the formulation

- **Viscosity Test:**

The results of the viscosity test showed that the cream exhibited medium to high viscosity, indicating a well-structured and suitable consistency for topical application. The formulation maintained its homogeneity during mixing without phase separation or noticeable changes in its physical structure, suggesting good formulation stability. This behavior reflects the product's ability to preserve its rheological and physicochemical properties during storage and use, which is an important indicator of overall product quality and performance.

- **Stability Study**

Parameter	Initial	After 1 week (37–40°C)
Color	Light green	Non change
Texture	Homogeneous	Non change
Phase separation	Absent	Abdent
Odor	Characteristic	Slight change

VII. Evaluation on human subjects:

- The prepared formulation was evaluated on a limited number of human volunteers presenting different skin conditions over a period of 7 days to assess its topical effects. Three distinct cases were included in this preliminary assessment: the first case involved skin exhibiting erythema and mild rash, the second case showed dryness and rough texture of the hands, while the third case involved facial skin affected by sunburn. The formulation was applied topically to the affected areas under controlled conditions throughout the study period, and observations were recorded regarding changes in skin appearance, irritation, and overall tolerability. This preliminary evaluation aimed to provide an initial indication of the product's potential soothing, moisturizing, and protective effects on various inflammatory and damaged skin conditions.

✓ The first case :

Visual examination of the skin before and after 7 days of treatment revealed a noticeable decrease in erythema (redness) and mild skin irritation, accompanied by an improvement in the overall appearance of the skin. These findings indicate a potential positive effect of the tested formulation on skin condition



Figure 39 : Skin Appearance Before and After Treatment

✓ The second case :

The anti-inflammatory activity demonstrated by the extract in the in vitro assay may explain the observed improvement in skin condition after 7 days of soap application. A reduction in skin irritation, scaling, and hyperpigmentation was visually observed, suggesting a potential soothing effect of the formulated product.



Figure 40 : Visual improvement of skin irritation and hyperpigmentation after 7 days of regular soap application

The third case:

After 7 days of treatment, the skin showed improved hydration and softness, with a more visible restoration of normal skin markings and a reduction in the rough appearance associated with chronic hand dryness.



Figure 41 : Before and After Treatment of Chronic Hand Roughness

CONCLUSION

This study evaluated the biological potential of the ethanolic extract of *Anabasis articulata*, a medicinal plant widely used in traditional medicine for the treatment of various skin conditions. Qualitative phytochemical analyses revealed the presence of several bioactive secondary metabolites, including phenolic compounds, flavonoids, tannins and saponins, known for their therapeutic properties.

Assessment of antioxidant activity using the DPPH method showed that the extract possesses a notable ability to neutralise free radicals, suggesting its capacity to protect tissues against oxidative stress. Furthermore, the protein denaturation inhibition assay revealed significant anti-inflammatory activity, confirming the traditional use of this plant in the relief of skin inflammation.

The study of antibacterial activity using the disc diffusion method demonstrated variable sensitivity of the tested bacterial strains to the extract, as evidenced by the formation of measurable inhibition zones. These results indicate that the extract possesses antimicrobial potential that may contribute to the prevention or reduction of skin infections.

Based on these promising biological properties, the extract was incorporated into topical formulations in the form of a cream and a soap. The preparations obtained exhibited satisfactory organoleptic characteristics as well as good preliminary stability. Their application to volunteers with certain mild skin conditions revealed a gradual improvement in skin condition, notably a reduction in signs of irritation and inflammation.

Overall, the results confirm that *Anabasis articulata* is a promising natural source of bioactive compounds that could be utilised in the development of dermocosmetic and phytotherapeutic products with antioxidant, anti-inflammatory and antimicrobial properties. However, further studies focusing on the identification of active

molecules, toxicological evaluation and larger-scale clinical trials are still required to confirm its efficacy and safety of use.

Recommendations

1. To continue research on the biological properties of wild desert plants and further explore their pharmaceutical and cosmetic applications.
2. To promote the valorization of local desert plants as a sustainable natural source of bioactive compounds with added economic value.
3. To conduct advanced phytochemical studies aimed at identifying, isolating, and characterizing the active compounds responsible for the observed biological activities.
4. To develop innovative pharmaceutical and cosmetic formulations based on extracts of desert medicinal plants.
5. To evaluate the economic feasibility and market potential of products derived from desert plants at both national and international levels.
6. To strengthen collaboration between universities, research laboratories, and industrial partners in order to facilitate the transfer of scientific findings into practical applications.
7. To encourage investment in the cultivation, conservation, and sustainable exploitation of medicinal desert plants.
8. To investigate the efficacy of aqueous extracts and compare their biological activities with those of alcoholic extracts within the same pharmaceutical and cosmetic formulations.
9. To expand future research to include other Algerian desert plant species with promising therapeutic, pharmaceutical, and cosmetic potential.

Abstract

Medicinal plants remain an important natural source of bioactive compounds despite advances in modern medicine. Among them, *Anabasis articulata* is traditionally used in folk medicine to treat various skin disorders, including inflammation, eczema, and skin irritation, and may also help inhibit bacteria associated with skin infections.

This study aimed to evaluate the antioxidant and anti-inflammatory activities of the ethanolic extract of *Anabasis articulata* and to characterize its phenolic compounds using qualitative and quantitative analyses. The aerial parts of the plant were extracted using ultrasound-assisted extraction with an ethanol/water (70:30) solvent system, and the extraction yield was determined.

The results showed a high total phenolic content of approximately 528 mg GA/100 g of plant material. The DPPH assay revealed strong antioxidant activity with inhibition rates ranging from 54% to 67%, while the anti-inflammatory assay showed significant protein denaturation inhibition (48.3% to 98.87% at 800 µg/mL). Formulated products also demonstrated notable activity, with the extract-containing cream showing 44.94% inhibition, compared to 16.40% for the base cream, and 78.98% for the soap.

Overall, the findings highlight the strong biological potential of *Anabasis articulata*, supporting its traditional use and its promising application in cosmetic and therapeutic formulations for skin inflammation.

Résumé

Malgré les progrès de la médecine moderne, les plantes médicinales restent une source naturelle importante de composés biologiquement actifs. Parmi ces plantes, *Anabasis articulata* est traditionnellement utilisée en médecine populaire pour traiter divers troubles cutanés, notamment les inflammations, l'eczéma et les irritations cutanées, et pourrait également contribuer à inhiber les bactéries associées aux inflammations cutanées.

Cette étude visait à évaluer les activités antioxydantes et anti-inflammatoires de l'extrait éthanolique d'*Anabasis articulata* et à caractériser ses composés phénoliques à l'aide d'analyses qualitatives et quantitatives. Les parties aériennes de la plante ont été extraites par extraction ultrasonique dans un système de solvants éthanol/eau (30:70), et le rendement d'extraction a été déterminé.

Les résultats ont montré une teneur totale en composés phénoliques élevée, d'environ 528 mg GA/100 g de matière végétale. Le test DPPH a révélé une forte activité antioxydante avec des taux d'inhibition allant de 54 % à 67 %, tandis que le test anti-inflammatoire a montré une inhibition notable de la dénaturation des protéines (48,3 % à 98,87 % à 800 µg/ml). Les produits formulés ont également montré une activité notable, la crème contenant l'extrait présentant une inhibition de 44,94 %, contre 16,40 % pour la crème de base et 78,98 % pour le savon.

Dans l'ensemble, ces résultats mettent en évidence le fort potentiel biologique d'*Anabasis articulata*, ce qui confirme son utilisation traditionnelle et son application prometteuse dans les formulations cosmétiques et thérapeutiques destinées au traitement des inflammations cutanées.

لا تزال النباتات الطبية تشكل مصدراً طبيعياً مهماً للمركبات النشطة بيولوجياً على الرغم من التقدم الذي أحرزه الطب الحديث. تقليدياً في الطب الشعبي لعلاج اضطرابات جلدية متنوعة، بما في ذلك *Anabasis articulata* ومن بين هذه النباتات، تُستخدم نبات ذلك الالتهابات والأكزيما وتهيج الجلد، وقد يساعد أيضاً في تثبيط البكتيريا المرتبطة بالالتهابات الجلدية.

الإيثانولي وتوصيف *Anabasis articulata* هدفت هذه الدراسة إلى تقييم الأنشطة المضادة للأكسدة والالتهابات لمستخلص مركباته الفينولية باستخدام التحليلات النوعية والكمية. تم استخلاص الأجزاء الهوائية من النبات باستخدام الاستخلاص بمساعدة الموجات فوق الصوتية بنظام مذيب من الإيثانول/الماء (30:70)، وتم تحديد عائد الاستخلاص

DPPH غرام من المادة النباتية. كشف اختبار GA/100 أظهرت النتائج محتوى فينولي إجمالي مرتفع يبلغ حوالي 528 ملغ عن نشاط مضاد للأكسدة قوي بمعدلات تثبيط تتراوح من 54% إلى 67%، بينما أظهر اختبار مضادات الالتهاب تثبيطاً ملحوظاً لتغيير طبيعة البروتين (48.3% إلى 98.87% عند 800 ميكروغرام/مل). كما أظهرت المنتجات المركبة نشاطاً ملحوظاً، حيث أظهر الكريم المحتوي على المستخلص تثبيطاً بنسبة 44.94%، مقارنة بـ 16.40% للكريم الأساسي، و78.98% للصابون.

، مما يدعم استخدامها التقليدي *Anabasis articulata* بشكل عام، تسلط النتائج الضوء على الإمكانيات البيولوجية القوية لـ وتطبيقها الواعد في التركيبات التجميلية والعلاجية لالتهابات الجلد

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