2023년 08월
석사학위논문

보스웰리아 (*Boswellia serrata*) 추출물의 향장소재 적용을 위한 항산화와 항균활성

조 선 대 학 교 산 업 기 술 창 업 대 학 원

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Antioxidant and Antimicrobial Activity of *Boswellia Serrata* Extract for Cosmetic Ingredient

2023년 08월 25일

조선대학교 산업기술창업대학원

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2023년 05월

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ABSTRACT

Antioxidant and Antimicrobial Activity of *Boswellia Serrata* Extract of Cosmetic Ingredient

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Boswellia serrata resin, which is an important source of gum oleoresin known as Indian frankincense and is well documented for its pharmaceutical properties due to its chemical structure, antibacterial and antioxidant properties, and the presence of several compounds such as polyphenols, phenols, and terpenoids.

In the experimental study, it was observed that *Boswellia Serrata* resin extracts inhibited antibacterial activity in all strains for the relevant concentrations. The diameter of the zone of inhibition for the *B. serrata* extract for *S. epidermidis* ranged from 13.3±0.58 to 10.3±0.58 mm, for *M. furfur* from10.6±0.58 to 9±0 mm, for *M. pachydermatis* from13.25±0.35 to 9.75±1.06 mm, and for *C. acnes* from 11.83±0.29 to 9.5±0 mm in the anaerobic jar.

antioxidant activity was measured with DPPH It was confirmed that there was higher activity in the Water Fr. compared to the Other fractions; respectively, Water Fr.

showed the highest scavenging activity 902.19 ± 35.53 μg/mL, Ethyl acetate Fr. 20436 ± 652.19 μg/mL ,70% EtOH Fr. 8627.74± 369.22 μg/mL, and the Hexane Fr. Shows No scavenging activity.

According to ABTS assay, the Water fraction demonstrated the maximum scavenging activity with a scavenging activity of 1845.08 ± 2265.74, followed by the ethyl acetate fraction with a scavenging activity of 12167.16 ± 8152.82 μg/mL.

polyphenol and flavonoid content in the Water Fr. was the highest; it reached TPC 32.15 ± 0.75 ㎎/mL and TFC 20.29 ± 1.47 ㎎/mL.

This study shows that the *Boswellia serrata* resin have some biological activities, and if they differ in terms of effectiveness and activity, they can be considered a good component of cosmetic products.

Ⅰ. Introduction

1.1. Background of the study

1.1.1. Herbal cosmetics

Herbal cosmetics are products manufactured with phytochemicals from various botanical sources that affect skin functions and provide nutrients for healthy skin or hair[1] Cosmetics are materials that are intended to be rubbed, poured, sprinkled, sprayed, injected into, or otherwise applied to the human body or any component of it for washing, beautifying, promoting attractiveness, or changing the appearance[2] Herbal cosmetics are products made with one or more herbal substances legally used to provide specific cosmetic benefits exclusively and a basis for various cosmetics[3] Active compounds found in medicinal plants are substances produced by the plant's natural metabolism and are crucial in treating many human illnesses, particularly infections brought on by bacteria[4] Plant antimicrobials contribute significantly to the eradication of infections caused by pathogenic microbes[5] These active components have multiple functions, including improving skin elasticity, preventing collagen degradation, protecting against UV radiation by antioxidant property and delaying the aging process of the skin by smoothing out wrinkles[6] Individuals' skin and hair beauty are influenced by their health, routines, daily activities, environment, and upkeep[7] Utilizing a range of herbs and plants, the science of Ayurveda enabled the development of efficient Ayurvedic cosmetics. Ayurvedic cosmetics adorn the face and shield the body from external impacts[8] Many herbal cosmetics are developed and extensively used in daily life. Herbal cosmetics like facial washes, conditioners, soaps, shampoos, and others are popular with the general public. Their best quality is that only herbs and shrubs make herbal cosmetics. Plant cosmetics, often known as ayurvedic, still have the same beneficial properties. Additionally, instead of harming the body, the natural elements of the herbs nourish it with nutrients and other advantageous minerals[8] Since the beginning of the practice of medicine, natural materials with such a plant origin have been used in healthcare. The evaluation of phytochemicals for pharmaceutical development has been widespread in recent decades. However, only a tiny handful of these plant species have received a thor-

ough scientific inspection. Therefore, research into the bioactivities of these plants and compounds is necessary. Even today, some of these historically used plants and products derived from plants are still important pharmacologically. One such healing herb is *Boswellia serrata* (Burseraceae)[9]

1.1.2. *Boswellia serrata*

Natural resins have played an essential role since ancient times, as they were considered among the plants with primary resources for food, flavors, and aromas. They are considered high-value ingredients for being an important component in the manufacture of human medicines. These adhesives have also been utilized as coating materials, cosmetic compounds, fragrances in religious ceremonies and daily rituals, and for their different medicinal properties[10]

Boswellia serrata resin were used extensively in ancient times by the Hindus, Babylonians, Persians, Romans, Chinese, Greeks and early Americans for incense and embalming. They firmly believed that the smoke and aroma produced by these materials when burned with fire not only helped to lift their spirits but also to appease their gods. Their collective life revolves largely around the burning of these natural resins. To prevent evil spirits from affecting their spirits or to commemorate the dead or the living, they burned these resins during sacrifice ceremonies and as part of their daily rituals[11] Since ancient times, these species have been utilized for their medicinal and aromatic qualities. As a result, the ethnobotany of their immediate surroundings frequently emphasizes the importance of their trees and shrubs. The resins of this species have been used by indigenous communities for various purposes in traditional medicine, including as an antiseptic and disinfectant, an external agent (cosmetics), and a wound dressing[12]

Frankincense is a significant oleo-gum resin used in various industries, including the pharmaceutical, culinary, perfumery, flavoring, liqueur, beverages, cosmetics businesses. Since ancient times, people have valued frankincense for its ceremonial and sacred purposes, even before Biblical times[13] is one of the most popularly used essential oils in aromatherapy to treat breathing disorders. It facilitates respiration and benefits people with asthma. Additionally, it relieves the symptoms of colds, asthma, bronchitis, and laryngitis[14] used to treat various bacterial and fungal infections[15] utilized to cure malignant disorders as well based on numerous studies have demonstrated its efficiency

in combating human leukemia[16]

Due to its ability to regulate the release of immune cytokines and the presence of cortisone, which inhibits inflammation and does not have the adverse side effects associated with synthetic cortisone, frankincense resin is used in the treatment of a variety of illnesses as well as to strengthen the heart and brain, and treats forgetfulness, blood diarrhea, treat arthritis, and other infections[17]

For its fresh, balsamic, dry, resinous, slightly green note, frankincense oil is employed in perfumery as a fixative and in oriental bases, ambers, flowers, colognes, and manly scents[14] Due to its sweet scent, it is also used as incense[18]

1.1.3. Scientific classification

The family Burseraceae has between 560-600 species spread across 18 genera. This family (Burseraceae) is where *Boswellia serrata* resin, also known as olibanum or frankincense, The genus *Boswellia* is a little one with roughly 28 species [19] In honor of Johann Boswell, who identified 25 different *Boswellia* species, the genus *Boswellia* was named after his name[20] The Taxonomical Hierarchy and vernacular names of *Boswellia serrata* are given in table1, table2

Humans have used botanical remedies like the Indian frankincense tree (*Boswellia serrata*) as remedies since ancient times. It has significantly influenced the treatment of several diseases. A medium-sized deciduous tree known as *Boswellia serrata* is mainly found in Saudi Arabia, Oman, Southern Arabia, Yemen, India, Pakistan, Africa, Nigeria, Somalia, and Asia.

A medium to a big tree, the *Boswellia serrata* can reach heights of 18 meters and a width of 2.4 meters. The leaves have opposing leaflets and are imparipinnate and packed together at the ends of the stems, and are frequently serrated. The tiny, white flowers on this hermaphrodite plant develop in racemes at the axils. Its thin, green-ish-gray bark turns yellow or crimson as the plant's petals ripen that are imbricated, number from three to five, and ultimately take on the color of ash. The bark will exude an exudate containing oleo gum resin after being hurt or having a natural crack. The bark secretes tiny droplets of resin and sheds in brilliant crimson, papery, silky flakes. Golden yellow, clear, aromatic oleo gum resin ultimately turns into crusts, tears, or drips that are brownish-yellow [19] (Figure1) Frankincense resin is harvested from the tree by creating an incision or wound in its bark that looks like milk or resin, then dries outside to appear like olibanum[23] (Figure2) which is then kept in a bamboo basket constructed especially for storage. The semi-solid gum resin is left in the basket for about a month while the fluid inside flows out. The gum resin, the semi-solid to the solid portion of the residue, progressively solidifies to form amorphous, tear-shaped products with an aromatic scent. It is then manually cleaned of all impurities, such as bark fragments, during the process of being broken into tiny bits with a wooden mallet or chopper. After that, the gum-resin is rated based on its flavor, color, form, and

size[22] Color, scent, cluster size, tree age, and purity, harvest season, and geographic position of the plant source are some of the variables that affect the quality and type of luban (Frankincense resin) is offered commercially in four grades, under the Arabic names Hoojri, Najdi, Shathari, and Shaabi (Figure3) There are four geographical locations in Oman, specifically the Dhofar region, where the resins is harvested. Hoojri Grade I resins, is distinguished by its lighter color and larger mass size than the rest of the species. This type it is gathered from trees that grow in the north of the Samhan Mountains. It costs $83 per kilogram "It is the sample used in the present work". While the Grade II, which is Najdi, is distinguished by its pale yellow color. It is gathered from a plateau that is hidden by mountains of Dhofar. It costs 67$ per kg. Shathari, Grade III resin it is darker color collected from northwest Dhofar, costs $31 per kilogram. Finally, Shaabi, Grade IV , which is also darker color and collected from valleys, costs only $15 per kilogram[14]

Table 1. Taxonomical Hierarchy of *Boswellia serrata* [21]

Kingdom	Plantae-Plants
Division	Angiospermae
Class	Dicotyledoneae
Order	Geraniales
Family	Burseraceae
Genus	Boswellia
Species	Serrata

Table 2. Vernacular names of *Boswellia serrata* [22]

English	Indian olibanum or Indian frankincense
Arabic	Luban or Luban dhakar or Luban mur or luban omani
Hindi	Kundur, salai
Bangali	Kundur, salai
Gujarati	Dhup, Gugali
Kannada	Chitta, Guguladhuph
Malayalam	Parangi, Saambraani
Tamil	Parangi, Saambraani
Telugu	Phirangi, Saambraani
Sanskrit	Ashvamutri, Kundara, Shallaki

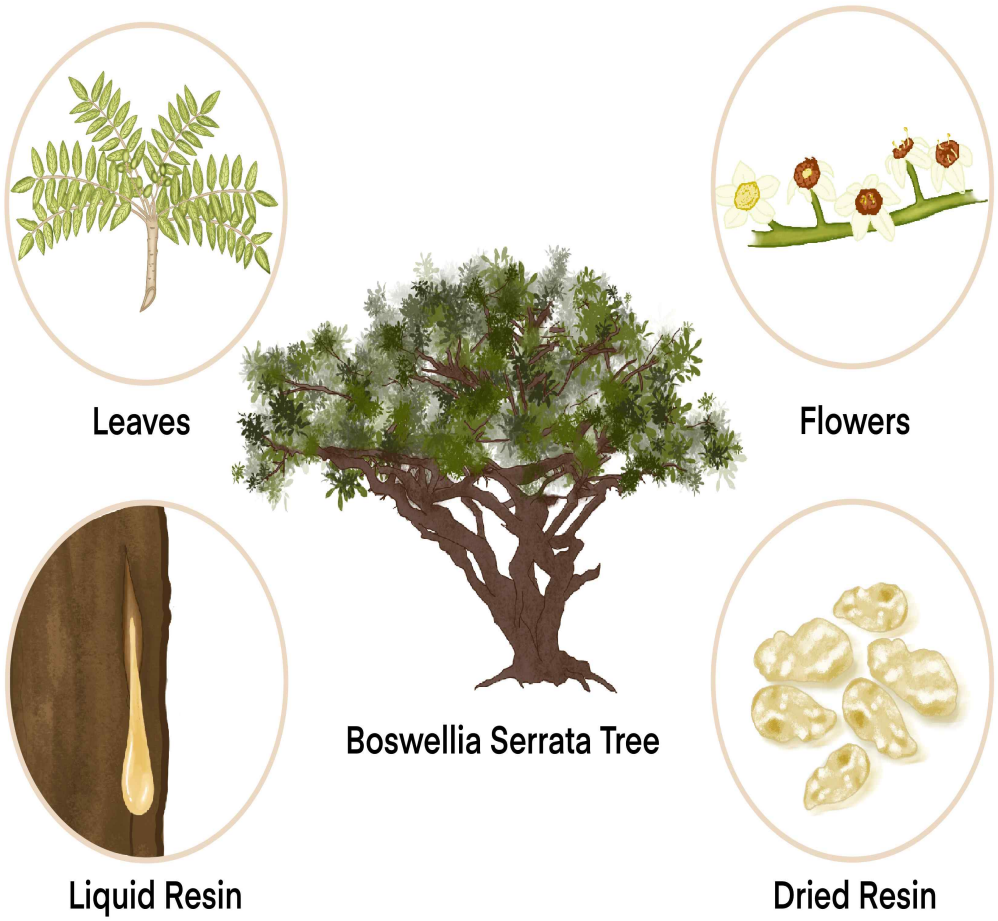


Figure 1. Tree parts of *Boswellia Serrata*.

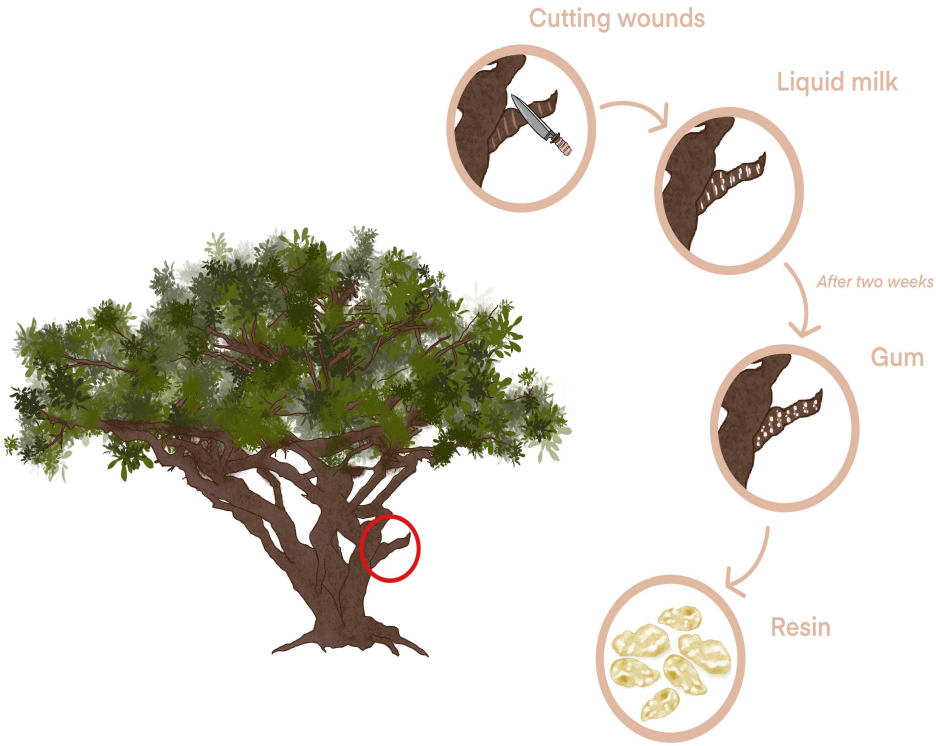


Figure 2. *Boswellia Serrata* resin extracted method.

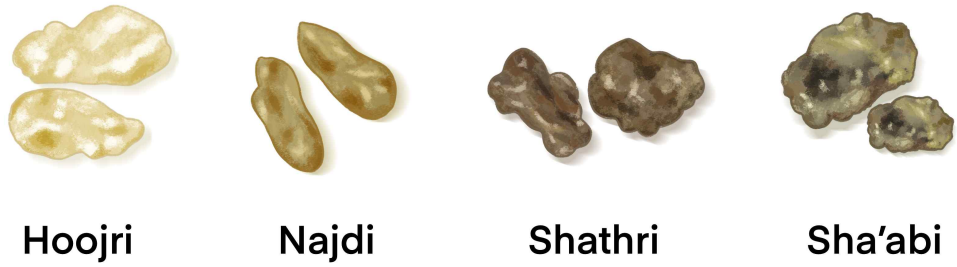


Figure 3. The four grades of *Boswellia Serrata*.

1.1.4. Economic importance

Arabs, Middle Easterners, Indians and even Africans are interested in the *Boswellia serrata* plant, because of its social, religious and economic importance in their countries.

It is used on a daily basis, especially in the homes of Arabs, because they believe that it helps to clean the house of bad energy and toxins. However, it helps to improve mood and get rid of anxiety.

Also, based on its social standing, it is given as a very precious gift on special occasions.

Oman is the country that produces the most *Boswellia serrata* plant, and frankincense is called Omani because of the interest of the Arabs in frankincense.

There is a special tourism in the Dhofar region in Oman to buy the finest types of Omani frankincense, which they call (incense and perfume tourism).

Subsequently, the world's attention became focused on *Boswellia serrata*, as many pharmaceutical, cosmetic, and fragrance industries include the *Boswellia serrata* plant.

a. medical uses

The resin is one of the most important herb medicines with remarkable efficacy in many therapeutic fields[24] Asthma, Crohn's disease, osteoarthritis, rheumatoid arthritis are the most prominent medical conditions that *B. Serrata* is used to treat. In addition, it's employed to cure bronchitis and cough[19] Use for skin conditions, corneal ulcers, osteoarthritis, dysentery, inflammatory conditions that last a long time, wound recovery, and diarrhea[25] used as a weight-loss aid[26] and is advantageous for liver fibrosis[27] and several cancers[19]Colitis and ulcerative colitis are both treated and prevented with *Boswellia* resin. In the cerebrovascular system, *B. Serrata* exhibits adequate antioxidant

activity[28] used for antipyretic, anti-sclerotic, and analgesic[29] in pain, arthritis, including osteoarthritis, allergies, and inflammatory bowel illness[30] It has additionally been utilized in mouthwashes as an antimicrobial[31] also for the treatment of chronic inflammatory illnesses[32] or the avoidance of skin and nail diseases[33] also benefits of antiulcer, antiulcerogenic, antibacterial, and psychopharmacological effects[34]

b. Industrial uses

Cosmetology:

Cosmetic industries have become one of the leading industries in developing countries, as these industries contribute to the country's economic growth.

International cosmetic companies depend on manufacturing skin, hair, and body care products from natural plant sources. On healthy skin, a look that is free from skin infections that affect most people.

There are numerous applications for *Boswellia serrata* resin in cosmetics, including anti-aging, soothing, and anti-inflammatory properties. It can also encourage quicker skin regeneration and increase skin elasticity to lighten the skin. Some of the global cosmetic products includes *B. Serrata* resin extracts are compiled in a table 3.

Perfumery:

Frankincense is of very high value in the manufacture of scented products due to its beautiful aromatic scent, as it is an essential ingredient in the manufacture of incense, perfumes, potpourri, creams, lotions, soaps, and detergents. It is frequently incorporated into meditation combinations since it bolsters the soul and aids in achieving a deeper level of meditation and relaxation[35] Because it holds its aroma for so long—some say indefinitely—frankincense is a favorite ingredient in potpourris. These days, it is still used for making incense, perfume, and medicines. Additionally, it is a component of numerous contemporary perfumes[36] It is known to be helpful as a fixative in pot-

pourris and perfumes in addition to providing a unique fragrance to any blend. It is utilized by perfumers in Oriental bases, ambers, powder perfumes, floral perfumes, citrus colognes, spice blends, violet perfumes, manly fragrances, soaps, lotions, and creams, among other things, as an absolute (by alcohol extraction), oil, or resinoid (by hydrocarbon extraction)[35]

Food and beverages:

A few businesses that employ frankincense products include the beverages, confectioneries, gelatins, nut goods, puddings, cans of vegetables, candies, chewing gum, and most of food industry. In addition, they are frequently utilized in rubber products as releasing agents, adhesive thickeners, stabilizers, flavor enhancers, fixing and emulsifying substances in culinary products. 500 tonnes or so of olibanum are imported into the Middle East, especially Saudi Arabia, to produce chewing gum[35]

Table 3. products containing *B. Serrata* resin extracts in cosmetics

Product Name	Function
united states of America	
Aveda—outer peace™ acne relief pads	Eliminate blackheads and stop fresh breakouts from occurring.
I image—CLEAR CELL clarifying salicylic tonic	Assist in calming sensitive skin and refresh and clear congested pores.
Aveda—men pure-formance™ conditioner	Refreshes scalp.
Dermadoctor—Ain'T Misbehavin' Intensive 10% Sulfur Acne Mask & Emergency Spot Treatment	Reduces the appearance of blackheads and spots. Additionally, it aids in skin healing.
Flexpower—Soothe Lotion	Soothes, anti-inflammatory.
Found—Marshmallow Calming Face Serum	Skin conditioning.
Aveda—Outer Peace™ Foaming Cleanser	Thorough pore cleaning without causing skin irritation or excessive drying.
Kate Ryan—Collagen Booster Intense Repair Serum	Reduces lines and wrinkles.
LANCER—Soothe and Hydrate Serum	Balances skin tone while reducing skin redness.
Skin Actives—Collagen Serum	Enhances the texture and tone of the skin.
Kate Somerville—Liquid Exfolikate	Soothes skin.
New Vitality Lumatone—Anti-Aging Eye Cream	Antiaging.

Table 3. (Continued)

Product Name	Function
Asia countries (South Korea, Japan, Indonesia, Malaysia, Thailand)	
Smooth-E—Acne Treatment Hydrogel	Reduce acne inflammation, treat acne, and kindly calm the skin.
Dermedics—YOUTH EXPERT™ Instant Relief Eye Serum	Anti-irritant.
Dermedics—MESO CALM Instant Soothing Elixir	Relieves irritability.
Dermedics—YOUTH EXPERT™ Physiological Micellar Water	Anti-irritant.
NPURE—Day Cream Centella	Antiacne.
Mitomo—Hyaluronic Acid + Lithospermum Facial Essence Mask	Brightening, moisturizing, and refining.
Yadah—Anti-T Mist	Revitalize and smoothens skin.
Europe countries (UK, Italy, Spain, Netherlands)	
Bioearth—Siero Idratante Lenitivo	Soothes skin.
Cantabria Labs Biretix—Gel Ultra Purifying	Hydrating and soothing activity.
Dermalex—Rosacea Treatment	Relieve different skin conditions.
Biodermal—Couperose Crème	Soothes skin.
ITreatSkin—Neem Cream	Soothes and reduces skin Inflammation.

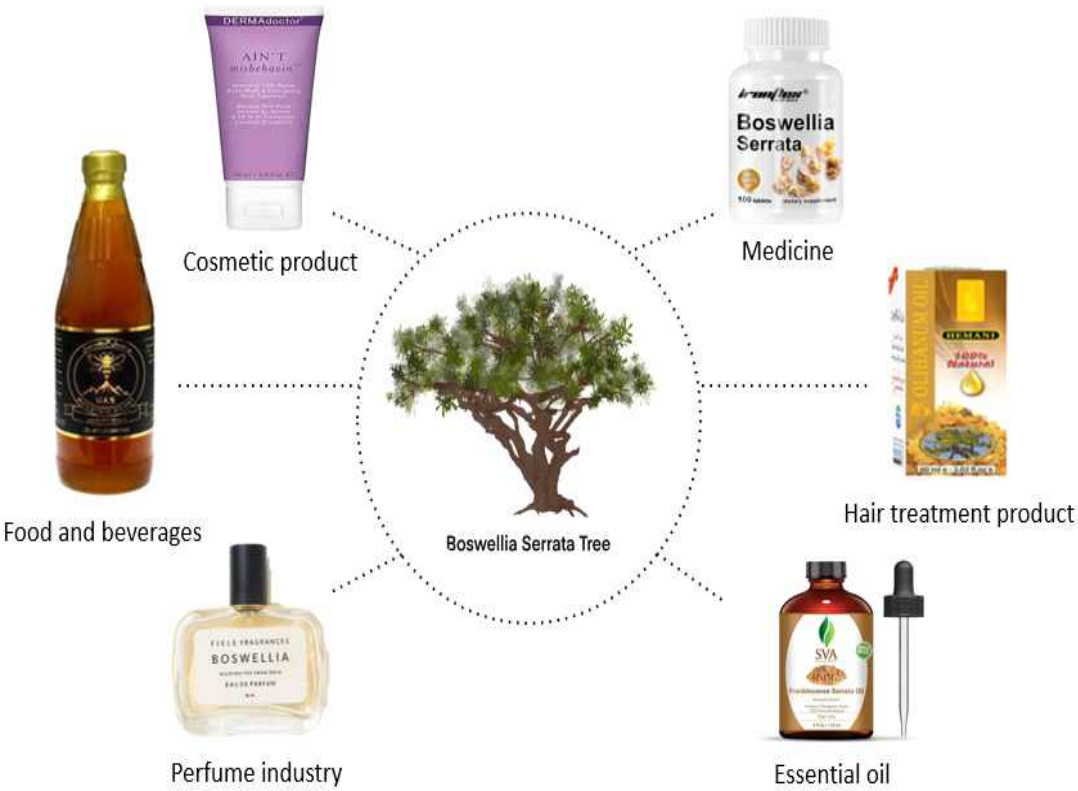


Figure 4. products containing *Boswellia Serrata* resin extracts

1.2. Antioxidants

It serves as a protection mechanism to shield the body's cells from harm. The body's enzymes and some nutrients consumed in everyday food make up antioxidants. Free radicals lose their capacity to oxidize after they form, become resistant, and change into another form. A free radical is an atom or molecule with one electron in the outer orbit. This forces it to seek out the lost electrons from other body compounds, damaging the body's cells by rupturing the barrier surrounding them. It does this by interacting with the phospholipids in cell membranes, which causes damage to everything from DNA to the collagen layer of the skin.

Antioxidant proteins protect cells from potential damage caused by free radicals. Accurate identification of proteins and understanding their role in antioxidant activity is critical in contributing to delayed aging[37]

1.2.1. Definition

Oxidation is a chemical reaction, in an oxidation process hydrogen or a material transfers its electrons to an oxidizing agent. Oxidation can generate free radicals. processes. These radicals can spark subsequent chain reactions. A cell may sustain harm or even perish when the chain reaction takes place inside of it. Additionally, oxidative stress both causes and results in illness. Protein molecules known as antioxidants stop these chain reactions by eradicating the free radical intermediates and prevent additional oxidation processes. Antioxidants are frequently reducing substances like thiols, ascorbic acid, or polyphenols because they are oxidized themselves in order to accomplish this[38] The definition can be summarized as that an antioxidant is "Any chemical that significantly slows down or prevents the oxidation of a substrate when present in concentrations below those of the substrate" Both compounds with an enzymatic and non-enzymatic nature are covered by this classification. Naturally, the diversity of antioxidants must correspond to that of oxidants[38]

1.2.2. Free Radicals and Oxidative Stress

Extrinsic damage to the skin arises from various causes: Ionizing radiation, high levels of stress on physical and emotional, alcohol use, poor diet, overeating, environmental pollution, and UV radiation exposure (UVR) (Figure4) when the formation of ROS in the skin caused by UV exposure surpasses the target cell's antioxidant defense capacity, oxidative stress results[39] Acute UVR exposure reduces the activity of the catalase enzyme in the epidermis and elevates protein oxidation[40]

According to estimates, UVR contributes up to 80% of all environmental factors, making it the primary environmental factor influencing the occurrence of skin cancer and skin aging[41] UVR causes molecular reactions in the human epidermis primarily through the photochemical production of ROS, particularly hydroxyl radical, singlet oxygen, superoxide anion, and hydrogen peroxide (H2O2)[42] UVR passes through the skin, enters the cells, and interacts with DNA to cause the creation of photoproducts that render DNA inactive. There are two distinct ways that UVR might harm an organism: (a) the cellular components directly absorb the incident light, creating excited states that trigger a chemical reaction; and (b) pathways for photosensitization, in which light is absorbed by endogenous (or exogenous) sensitizers that have been excited to their triplet states. Two methods exist by which the energized photosensitizers can harm cells: (a) the production of free radicals through methods for hydrogen abstraction and electron transport, or (b) the production of singlet oxygen through energy transfer with oxygen[43]

1.2.3. Skin Antioxidants

Antioxidants serve as a network of defense for the epidermis. They include enzymatic antioxidants like glutathione peroxidase, superoxide dismutase, and catalase, as well as nonenzymatic low-molecular-weight antioxidants such as different forms of vitamin E, vitamin C, glutathione (GSH), uric acid, and ubiquinol.[44] The outer layer of the skin, known as the epidermis, contains a higher concentration of antioxidants than the dermis. Potent antioxidants include ascorbate, carotenoids, and sulphydrils, which are

also abundant in the epidermis. The water-soluble antioxidants glutathione, glucose, pyruvate, uric acid, ascorbic acid, and bilirubin are all present in plasma. Ubiquinol-10, lycopene, -carotene, lutein, zeaxanthin, and alpha-carotene are lipid-soluble antioxidants similar to alpha-tocopherol[45] The most noticeable antioxidant in the lipophilic phase is α-tocophero, while the cytosol contains the greatest concentrations of vitamin C and GSH. According to molar ratios, hydrophilic non-enzymatic antioxidants like GSH, uric acid, and L-ascorbic acid appear to be the most abundant antioxidants in human epidermis[46] It was discovered that the stratum corneum (SC) contains both hydrophilic and lipophilic antioxidants. The SC was discovered to contain GSH, uric acid, and vitamins C and E (both αɣ and α-tocopherol)[47]

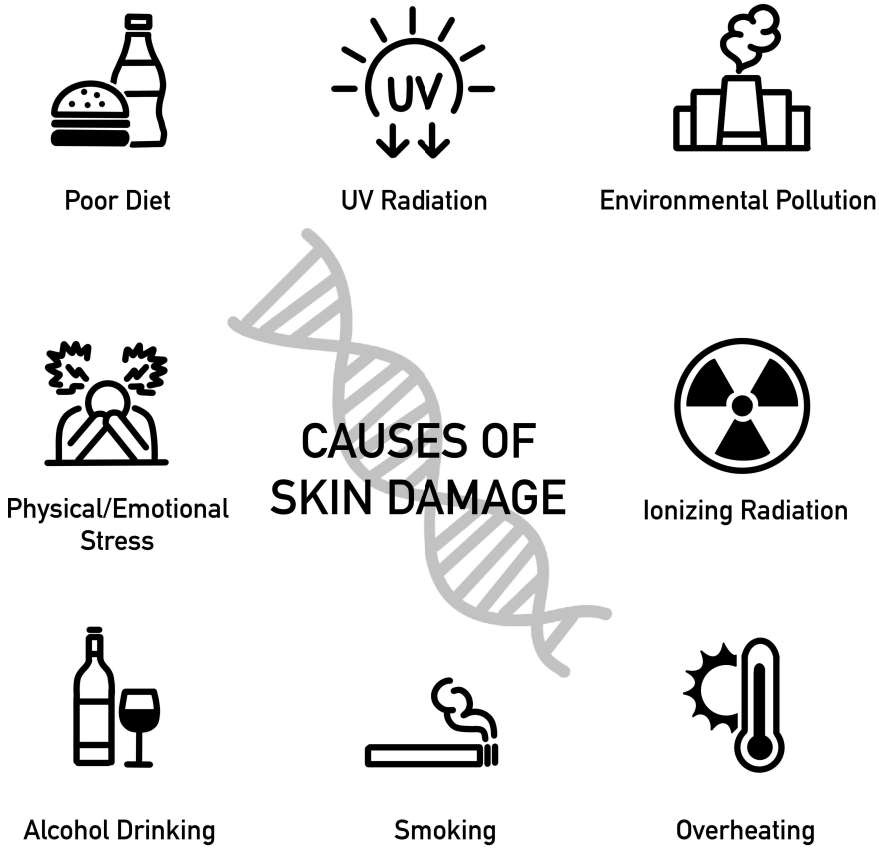


Figure 5. Environmental causes causing the formation of free radicals.

1.3. Antimicrobial

Threats from bacterial diseases to human health have been on the rise. Numerous anti-infectious agents have been developed to efficiently reduce bacterial contamination due to advances in biological technology and general hygiene. Antibiotics have been widely used to combat bacteria and have successfully treated many illnesses. However, one of the biggest threats to public health continues to be the emergence of drug resistance from inappropriate antibiotic use.

A substance known as an antibiotic prevents the growth of (bacteriostatic agent) or kills microorganisms (microbicide)

Antimicrobial drugs can be categorized based on the microbes they are most effective against. For example, antibiotics are used against bacteria, while antifungals are used against fungi. They can also be grouped according to how they are put to use. The use of antimicrobial drugs to treat and prevent infections is referred to as antimicrobial prophylaxis and antimicrobial chemotherapy.

1.3.1. Defense systems of the skin

The epidermis is a barrier to stop the spread and invasion of dangerous germs. Among the cutaneous antimicrobial defense mechanisms are mechanical rigidity of the stratum corneum, low moisture content, lysozyme production, acidity (pH 5), and defensin[48] Generally, the skin's surface areas are dry, preventing bacterial growth. Colonizing bacteria are eliminated via the sloughing of dead keratinocytes. Skin is cooler than normal body temperature and slightly acidic; most bacteria survive best at a neutral pH and temperature of 37°C. If organisms get beyond human cutaneous defenses, the immune system or skin-associated lymphoid tissue (SALT) steps in as the next line of defense[49]

1.3.2. Bacterial growth on skin

Numerous bacteria have a complex habitat on the epidermis. The human epidermis is initially sterile, but it quickly becomes a host to residing bacteria after birth. The variety and density of bacteria are influenced by anatomical location, ambient humidity, the quantity of sebum and sweat produced, the host's hormonal condition, and age[50] In relation to the host, the bacterial epidermis flora is parasitic, symbiotic, or commensal. Although changes the type of interaction created is frequently intrinsic to the bacteria, even if the host's immunological condition is recognized to have a considerable influence. The ability of germs to stick to skin epithelium and thrive in mostly dry environments, and acidic environment, and then quickly read here during the usual desquamation process leads to persistent colonization[51]

1.3.3. Protection by colonizing bacteria

Commensal bacteria can grow on the skin, which helps to both directly and indirectly safeguard the host from pathogenic bacteria. The production of bacteriocins, the creation of toxic byproducts, the formation of minimal potential for reduction-oxidation, the depletion of vital nutrients, the prevention of the adhesion of rival bacteria, the Toxins' breakdown and blockage of translocation are just a few examples of the direct effects. competition between commensal microbes for resources, niches, and receptors. For instance, *Staphylococcus epidermidis* binds to keratinocyte receptors and prevents pathogenic *S. aureus* from adhering to the skin[52] Commensals have the ability to produce bacteriocins, which are species-specific antibiotics. As an illustration, the *S. aureus* strain 502A produces bacteriocins that prevent the growth of other virulent *staphylococcal* pathogens[53] Indirectly, microbes can cause the host to produce more interferon, cytokines, and phagocytosis, as well as more antibodies, phagocytosis, and clearance mechanisms. For instance, Propionibacterium acnes releases fatty acids from lipid decomposition, which acidifies the environment and stops *Streptococcus pyogenes* from growing[54]

1.3.4. Microbes that cause skin diseases

Skin acts as a protection barrier and is home to numerous colonizing microorganisms. Generations of dermatologists have claimed that microbes affect the natural course of various skin conditions based on study and clinical observation. For instance, *Staphylococcus epidermidis* is commonly cultivated from healthy skin and may shield people from pathogenic bacteria[55] The most frequent bacterial skin and skin structure infections are Scarlet fever, acute paronychia, staphylococcal scalded skin syndrome, cellulitis, erysipelas, folliculitis, furunculosis, carbuncles, wound infections, abscesses, and cellulitis[56] Bacteria are only one aspect of the relationship between microbes and human epidermis. Athlete's foot and chickenpox are just two examples of the well-known human infections caused by fungi and viruses[57] a wide range of additional factors may influence the microbial communities living on and in the epidermis. External elements including clothing types, use of lotions/creams, cleansers, deodorants, or antiperspirants, regularity of personal hygiene, seasonal temperature, ambient humidity, past antibiotic use, and other environmental surfaces[58]

Microbes can cause skin infections. A wide variety of microorganisms can cause skin infections. Most cases are brought on by *streptococcus* or *staphylococcus aureus* can be treated with topical antibacterial. Table 3

Table 4. The most common microbial infection

Infections	Microorganisms	Description	Ref.
Nonbullous Impetigo	*staphylococcus aureus*	Lesions of nonbullous impetigo typically begin on skin of the face or extremities. a small vesicle or pustule first appears, then quickly transforms into a honey-colored, crusted plaque with a diameter typically less than 2 centimeters. Lesions are typically accompanied by little to no pain; Pruritis occurs occasionally, and in up to 90% of cases, regional adenopathy is discovered.	[59-61]
Bullous Impetigo	*staphylococcus aureus*	Most frequently, skin on the cheeks, buttocks, trunk, perineum, and extremities develops flaccid, transparent bumps. Bullae readily rupture, leaving a thin scale rim at the edge of a moist, shallow erosion.	[60, 62]

Infections	Microorganisms	Description	Ref.
Erysipelas	Group A beta-hemolytic *Streptococcus pyogenes* (GABHS)	Small erythematous patch with well-defined, slightly raised borders that quickly turn brilliant red, edematous, indurated, and shiny. It is most commonly seen on the central face and legs. The infection spreads quickly, unevenly, and laterally over a short period, and it has the potential to worsen into an infection with the development of bullae and severe necrosis.	[63]
cellulitis	*streptococci* and *S. aureus*	Hemorrhagic cellulitis may result from petechiae and ecchymoses, with numerous bullae developing on inflamed skin. are rapidly spreading skin diseases that are more severe than erysipelas and affect the subcutaneous tissues. Regional lymphadenopathy and lymphatic streaking associated with the condition are intermittent, and local consequences like necrosis and abscesses are more common than in erysipelas.	[64]

1.3.5. Antibacterial

Antibacterial activity is linked to substances that kill or retard the development of bacteria locally while not generally being toxic to nearby tissue. The majority of modern antibiotics are natural substances that have been chemically altered[65] The agents can commonly fall into two categories: bacteriostatic, which inhibits bacterial development, and bactericidal, which kills bacteria. Antibacterial medications are crucial in the battle against infectious diseases. However, due to their widespread use and abuse, bacterial resistance to antibacterial drugs is now a regular occurrence, which is a significant issue. Resistance is typically founded on evolutionary processes that happen during, for example, antibiotic therapy and can be passed down inheritably. Additionally, tolerance may develop through horizontal gene transfer via conjugation, transduction, or transformation. [66]

1.4. Research Trends and Composition

1.4.1. Research Trends

Due to the tight relationship between human life and plant life as food, botany research and identification are crucial. In addition to using plants as food, people have linked the diseases they suffer from to the plants that cover the earth's surface and have used these plants or parts of them as medicines.

Since the discovery of the advantages of plant extracts until now, many developed nations have turned their attention to the significance of plant extracts, and the pharmaceutical and biological industries are flourishing as a result[67] With the discovery of pure and efficient plant compounds in the nineteenth century due to the development of chemical sciences and laboratories, the use of natural extracts continued and became a significant part of molecular sciences. This led to the identification and extraction of many compounds, such as polyphenols, and the importance of plant compounds that have medicinal properties.

In America, 25% of medicines are herbal, an environmentally friendly product free of synthetic chemicals is now widely accepted by people[68]

Additionally, the majority of the plant includes one or more chemicals, either naturally or through active chemicals extracted from it, in small or large concentrations that can treat one or more specific diseases or lessen their symptoms.

The beauty field is seeing the emergence of a new business in addition to the pharmaceutical one: "green cosmetics." Since 2007, the market for natural and organic skin and body care items has increased by an average of 6% annually, reaching over $50 billion[69]

Since the beginning of time, people have been preoccupied with beauty and outward looks. As a result of numerous bothersome external factors, this leads to the development of melasma, wrinkles, hair loss or unwelcome hair growth, and skin diseases. Male or female, people were eager to find solutions to these issues and to present themselves in the best and most attractive way possible, so they took care of their

skin, its freshness, the length of their hair, its luster, and everything else related to beauty[70]

Different kinds of cosmetics emerged over time and became a necessity in the lives of the majority of people as human nature and living circumstances improved.

The types and uses of cosmetics differ, and among the best cosmetics that are significantly superior to other preparations are those made from only naturally occurring materials. It has a negative impact on the face, and many allergic individuals have discovered that natural products, whether in the form of oils, creams, or other formulations, work best for these issues.

Natural products play a part in all aspects of the body's health and beauty, not just in medical treatments. Natural extracts and essential oils can whiten and color-coordinate skin, remove excess hair, lengthen hair and smooth feet, and provide a variety of other health advantages.

In light of this, natural and organic cosmetics are still in high demand from consumers who have been influenced by recent media and social media posts providing facts about green cosmetics, who produces them, how they are better for your skin than conventional cosmetics, and the health risks of traditional colorants and poses. Health-conscious consumers purchase these products to limit their exposure to potentially harmful chemicals like parabens, and they demand that businesses be transparent about the ingredients used in the products they use on a daily basis. They also discuss what is required to create a product that falls into the category of eco-friendly products[71]

Manufacturers and business owners were under much pressure due to all these customer expectations and demands, so they began spending much money to encourage scientists and researchers to find natural-source compounds for use in developing new, marketable products[72]

1.4.2. Structure of the study

Boswellia Serrata resin are one of the primary resin used in this field because their chemical compounds have beneficial effects on the body, such as their anti-inflammatory, anti-bacterial and antioxidant effects. Therefore, this study aimed to find the best way to extract antioxidants and antimicrobial from *Boswellia Serrata* resin.

Boswellia Serrata is one of the considered one of the most important frankincense found in the homes of Arabs, Middle Easterners. Families trust this plant for its safe and practical uses. Recent studies demonstrated that boswellic acids and *B. serrata* extract have a significant safety margin According to many studies, it has also been reported for antioxidant, antimicrobial activity, which is attributed to compounds with free radical scavenging activity due to its phenolic content. The *Boswellia Serrata* resin extract generally contains boswellic acids, Fatty acids, and bioactive components. Therefore, the experiment was designed to antioxidant and antimicrobial properties *Boswellia Serrata* resin extract and assessment of the ability to root scavenging using DPPH and ABTS assay and measurement of phenolic components TPC and TFC. beside the experiment of HPLC analysis to confirm the polyphenols present in the extract.

In addition to containing effective antimicrobial materials, a test was carried out Antibacterial agar disc diffusion assay.

The purpose of this study is to investigate the possibility of using *Boswellia Serrata* resin extract as functional ingredients of cosmetics by studying the results of root scavenging and antibacterial tests according to the extraction method.

Ⅱ. Literally review

2.1. Review of research on *Boswellia serrata*

2.1.1. Ingredients and compounds of *Boswellia serrata*

The polysaccharides in oleo gum-resins (65% arabinose, galactose, and xylose) are soluble in water. The resins (30–60%) and essential oils (5%–10%) are soluble in organic solvents. The resinous part of *Boswellia serrata* possesses monoterpenes, diterpenes, triterpenes, tetracyclic triterpenic acids and four major pentacyclic triterpenic acids i.e. β-boswellic acid, acetyl-β-boswellic acid, 11-keto-β-boswellic acid and acetyl-11-keto-β-boswellic acid, responsible for inhibition of pro-inflammatory enzymes. One of these four boswellic acids, acetyl-11-keto-boswellic acid, is the most potent inflammatory enzyme inhibitor. 5-lipoxygenase[22]

According to a phytochemical analysis using According to thin-layer chromatography, terpenoids, phenolic compounds, flavonoids, and phenylpropanoids were the major constituents of *B. serrata's* gum resin[34]

a. **Resin \ Gum**

Oleo-gum resin analysis revealed: Moisture 10-11%, volatile oils 8-9%, resins 55-57%, gums 20-23%, and insoluble materials 4% - 5%.

The techniques for separating oleo gum resin into its various components and gum enzymes like diastase and oxidase have also been studied. The gum has 0.16% nitrogen in it by[73] The gum was hydrolyzed by heating it with 3% H2SO4 recognized the sugars as arabinose, xylose, and galactose after 8 hours by [74] Comparable to those made with 5% Acacia mucilage were tablets made with 9% *B. serrata* mucilage. identified water soluble protein of gum resin, 4-O-methyl-glucuronoarabinogalactan[25]

Boswellia serrata gum resin extracts are effective at treating several inflammatory diseases, include asthma, rheumatoid arthritis, osteoarthritis, inflammatory bowel disease depending on animal research and preliminary clinical trials[75]

b. Oil

A-thujene, a-pinenes, a significant ingredient, and b-phellandrene were discovered in minute quantities in the low boiling oil fractions. Terpenol, methyl chavicol, and sesqui-terpenes were the three main constituents that worked out the high boiling fractions in detail. It has also been claimed that acetyl-b-boswellic acid separation was accomplished using spectral data and interconversion. The qualities and applications of essential oils, as well as the methods for separating them from gum and resin.

Due to its diverse sources, oil has a wide range of physicochemical properties. A-pinene dipentene, phellendrene, cadinene, camphene, p-cymene, d-borneol, verbenone, and verbenol are some of the components of the oil. According to numerous research, the principal components of the essential oil include a-thujene (50%) a-pinene (6.2%), dlimonene (4.5%), p-cymene (14%), cadinene (4%), geraniol (0.8%), and elemol (1.3%). The main components are the a and b-pinenes and d-emonene. Terpinyl acetate 3.5%, methyl chavical 2%, linalool 1.5%, and terpinol 1% are present.[25]

c. Boswellic acids

boswellic acids in particular have been found to be active constituents; their chemical structures are shown in (Figure5)

The content of six boswellic acids [keto boswellic acid (1), 3-O-Acetyl 11-keto β -boswellic acid (2), α-Boswellic acid (3), β-Boswellic acid (4), 3-O-Acetyl-α-boswellic acid (5) and 3-O-Acetyl-β-boswellic acid (6)] had been used as the standard index to appraise the quality of boswellia gum resin and its products[76]

In 11-keto BAs (KBA) and 3-O-acetyl-BAs (AKBA), respectively, a carbonyl and acetyl groups are present, providing structural variation[77] The main anti-inflammatory properties of boswellic acids are attributed to suppression of leukotriene formation via inhibition of 5-lipoxygenase (5-LO) by 11-keto BAs (KBA) and 3-O-acetyl-BAs (AKBA)[75]

In addition to inhibiting human leukocyte elastase, which is produced in inflammatory

and hypersensitive conditions, boswellic acids also have antiphlogistic effects[78]

d. Terpenoids

On the basis of b-boswellic acid, which makes up more than 30% of the total triterpene acids, the estimation of the total triterpene acids present in the various forms of B. serrata was made. B-boswellic, 11 ketoboswellic, and acetyl 11-keto b-boswellic acids are all types of triterpene acids. Utilizing functional groups analysis, triterpene acids were estimated individually or in conjunction with one another. Acetyl and hydroxyl groups at position 3 and keto groups at position 11 were the functional groups examined[25]

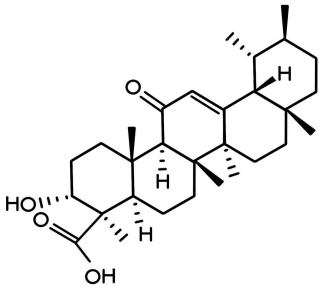
e. Fatty acids

The *Boswellia serrata* tree's bark contains Fatty acids like Myristate, Palmatic, Oleic, Linolic, Arachidate, Arachidatenate, and Lignocerate. It was discovered using a GLC-MAS tool, which has proven to be effective against bacteria[79, 80] The GLC technique was used to identify the fatty acids in the extract of frankincense resin. The equipment produced GLC-chromatograms and extractor retention times that were compared to standard chemicals. Each fatty acid's concentration in the extract was also known. The following fatty acids were identified: (Myristate, Palmatic, Oleic, Linolic, Arachidate, Arachidatenate, and Lignocerate). From highest concentration to lowest concentration, the fatty acids identified with the GLC device are as follows: (Palmatic 0.129, Myristate 0.119, Lignocerate 0.114, Lenolic 0.026, Arachidatenate 0.008, Oleic 0.007). Additionally, it displayed each fatty acid's concentration and retention period after being separated from olibanum. According to the study's by [80] Olic acid was found to be present in the lowest percentage 0.007 and palmatic acid in the greatest percentage 0.129 followed by the remaining separated fatty acids. Numerous studies have established that the *Boswellia serrata* plant includes a variety of fatty acids, including Oleic, Linoleic, Arachidic, Arachidonic, Palmitic, and Lauric acids[17]

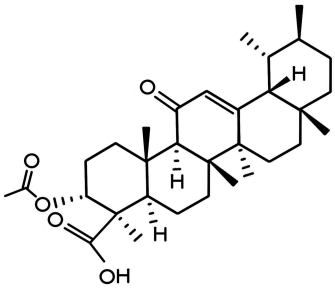
f. Phenols

The *Boswellia serrata* tree resin demonstrated that includes phenolic chemicals that have demonstrated their effectiveness as antibacterials, including thujene, camphene, b-pinene, myrcene, limonene, and cis-verbenol.by [34]

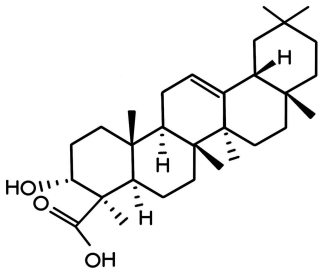
Previous studies have proven that Due to its anti-inflammatory properties, the frankincense resin of the *Boswellia serrata* plant, which contains free phenols, is used in the treatment of many human illnesses, particularly reducing the symptoms of arthritis. Additionally, the *Boswellia serrata* extract included free phenols in a variety of concentrations, and these had a somewhat stronger impact than the fatty acid extract on pathogenic microbes[17]



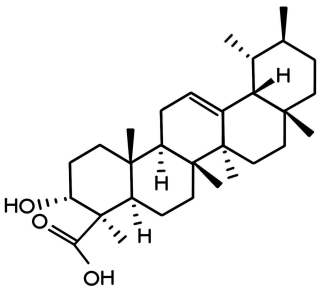
11Keto beta boswellic acid
(1)



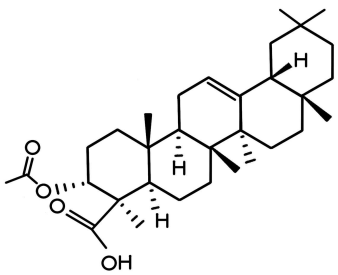
3-O-Acetyl 11-Keto beta-boswellic acid
(2)



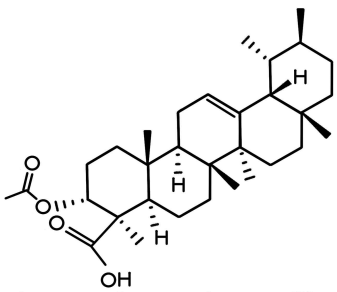
Alfa-Boswellic acid
(3)



Beta-Boswellic acid
(4)



3-O-Acetyl-Alfa-boswellic acid
(5)



3-O-Acetyl-Beta-boswellic acid
(5)

Figure 6. Chemical structures of boswellic acids.

2.1.2. Bioactive compounds in *Boswellia serrata*

The *Boswellia serrata* plant contains gum and essential oil. Monoterpenes, diterpenes, and sesquiterpenes are all present in their essential oil. Essential oils also contain phenolic substances and diterpene alcohol(serratol). The drug's gum component comprises Pentose and Hexose sugars and certain oxidizing and digesting enzymes. The major component of the resin is pentacyclic triterpene acid, whose active moiety is boswellic acid.[81] NMR and mass spectroscopy were used to corroborate the structure of the fraction produced 3-hydroxy-lup 20(29) ene-24-oic acid following further purification with EtoAC- Hexane (1:1)[82] *B. serrata* gum-resin samples from India and Africa that underwent HPLC analysis produced 12 different pentacyclic triterpene acids[21]

Pinene and cymene were discovered through thin layer chromatography (TLC) examination of the essential oil from *B. serrata* leaves using silica gel and spraying reagents with vanillin-sulphuric acid. Their Rf values were 85 and 33, respectively. While GLC tests using OV-17 and SE-30 at 69-200°C produced thirteen components, including d--thujene (32%), p-cymene, and d-limonene as minor constituents in the lower boiling fraction, and -terpineol, methyl chavicol, and four unidentified compounds in the high boiling fraction[83] Using a highly sensitive reverse phase HPLC technology, boswellic acids in *Boswellia serrata* were found and analyzed was used at 210 and 254 nm with an acidic mobile phase at 60oC[84]

Boswellia serrata n-hexane extract was steam distilled, and GC-MS analysis of the essential oil fraction revealed 33 components[21] comprising monoterpenes (9.9%) and diterpenes (7.1%), esters (62.1%), and alcohol (15.4%). This essential oil was discovered to contain the following compounds: α-thujene, α-pinene, camphene, sabinene, β-pinene, myrcene, o-methylanisole, αterpinene, hexyl acetate, p-cymene, 1-8-cineole, limonene, cis-β-ocimene, trans-β-ocimene, ɣ-terpinene, 1-octanol, terpinolene, linalool, 1-decanol, terpinen-4-ol, α-terpineol, 1- octylacetate, bornyl acetate, citronellyl acetate, neryl acetate, geranyl acetate, hexyl hexanoate, 1-decyl acetate, hexyl octanoate, isocembrene, cembrene, iso-incensole and incensole[85] By employing column chromatography with silica gel-G with n-hexane and ethyl acetat, the tetracyclic triterpene acids E, F, G, and H from resin of Boswellia serrata were obtained[21]

Boswellia serrata oleoresin was successfully adapted for determine using solid phase microextraction and gas chromatography/mass spectrometry the volatility and polarity of terpenoids. As a consequence, cembrane and incensole were captured as unique diterpenes. Additionally, 50 monoterpenes were obtained by gas chromatography at 40°C using poly-dimethylsiloxane/divinylbenzene fiber, with roughly 15 of them having a yield of more than 1%. after trimethylation yielded 15 triterpenes i.e. α-boswellic acid, β-boswellic acid, 3-acetyl-αboswellic acid, 3-acetyl-β-boswellic acid, α-amyrin, β-amyrin, 3-epi-αamyrin, 3-epi-β-amyrin, lupeol, 3-epi-lupeol, αamyrenone, β amyrenone, lupenone, 3α-hydroxy lup20(29)en-24 oic acid and 3-O-acetyl hydroxy lup-20(29) en-24-oic acid on GC-MS studies. In addition, three distinctive degradation products were discovered: 24-norroleana-3,12-diene (a), 24-norursa-3,12-diene (b), and 24-norlupa-3,20(29)-diene (c)[21] The key characteristics and chemical composition of B.serrata extracts are out-lined in the table 3.

Table 5. Main ingredients and compounds in *Boswellia serrata*.

ingredients and compounds in *Boswellia serrata*	Ref.
Galacturonic acid, glucose, galactose, fructose, sitosterol, phenol-o-cresol, m-cresol, p-cresol, thymol, and carvacrol are all sugars.The acid campholenic Campholytic acid and 2,2,4-trimethylcyclopent-3-en-1-yl acetic acid	[86]
percentage (97.3%) rich in limonene and e-ocimene. Sesquiterpene content in E-caryophyllene is (2.7%).	[87]
Resin acids comprise between 60% to 70% of the mixture, together with water-soluble gum (20%) and monoterpene essential oil (3%–10%).	[88]
oil(45%), α-thujene (12%), α-pinene (8%), sabinene (2.2%), β-pinene (0.7%), myrcene (3.8%), α-phellandrene (1%), pcymene (1%), limonene (1.9%), linalool (0.9%), perillene (0.5%), methylchavicol (11.6%), methyleugenol (2.1%), germacrene D (2.0%), kessane (0.9%), cembrene A (0.5%) and cembrenol (1.9%), a monoterpene 5,5-dimethyl-1-vinylbicyclo- hexane (2%) and m-camphorene (0.7%) and p-camphorene (0.3%)	[89]
Diterpenes, incensole, incensole acetate, and cembrenol (serratol)	[90, 91]
Lupeolic acids, oleanane(α-boswellic acids), ursane-(β-boswellic acids) , and lupane-type lipophilic pentacyclic triterpene acids, and an ether-insoluble fraction polysaccharides (arabinose, galactose, and xylose) soluble in water	[19, 92]

2.1.3. *Boswellia serrata* in cosmetology

Plants have been used in cosmetics since antiquity, and modern scientific research continues to center on this topic. It is now possible to draw even more intricate images because of advances in our knowledge of how plants and skin change over time. Plants are intelligent beings that respond to their environment by creating different metabolites. Applying phytomolecules to the skin impacts the skin's health and appearance through interacting with skin cells. Numerous plants with the potential to enhance modern cosmetic products have been identified through both physico-chemical research and ethnobotanical studies[93]

Plants offer precious active substances for both therapeutic and aesthetic uses. Humans have utilized products meant to improve skin issues and appearance for hundreds of years, and these products have evolved into modern cosmetics. Our skin is a physical barrier between ourselves and the outer world and protects us from danger. Plants have been proven to create compounds that help soothe and protect the skin. In addition, Modern cosmetics can adjust the skin's elastic qualities along with hydrating the skin and minimizing redness[94]

The major fibers that make up the skin's extracellular matrix are collagen and elastin; the former is in charge of tensile strength, and the latter is in charge of elasticity. The aging process is accompanied by a decline in collagen and elastin production and strength, which results in wrinkles[95] Additionally, the creation of the enzymes collagenase and elastase, which break down collagen and elastin is additionally responsible for the intrinsic aging of the skin[96]

Several things can cause damage to the outer skin, including intense UV radiation exposure, a poor diet, and physical and mental stress. Oxidative stress, which produces free radicals, is brought on by the production of reactive oxygen species by the impact of UV rays on the skin[41], And research has effectively demonstrated a clear link between free radicals and the onset of premature aging[97]

According to estimates, UV rays account for up to 80% of all environmental influences, making them the most significant environmental component in the development of

skin cancer and skin aging[41]

Some of the applied antioxidants have the ability to preventively block the negative effects of free radicals, resulting in normal generation of the structural proteins of the skin[97] Vitamins and antioxidants applied topically in cosmetics are thought to enhance protection and maybe even undo harm by neutralizing free radicals[98]

Since the skin serves as the body's external barrier against the environment, it is at the forefront of the fight against external influences to destroy free radicals. Free radicals are unpaired electron compounds that are very reactive that cause damage to the surrounding molecules and tissues. It is known that ultraviolet light and environmental pollutants are among the initiators to cause free radicals[99]

Several studies conducted on *boswellia serrata* material reported the presence of many compounds such as polyphenols and terpenoids, These terpenoids, which are thought to be the most potent components of Boswellia resin, are mostly represented by boswellic acids[100] The researchers discussed polyphenols' antioxidant properties. Terpenoids have been shown to have antioxidant capacity, and research has shown that they are highly active molecules that can help slow skin aging[101]

Since ancient times, the Arabs and Indians have used *Boswellia serrata* and considered it an essential plant in their culture for its cosmetic properties and countless benefits for skin and hair health.

Due to its antioxidant, antibacterial and anti-inflammatory properties, it helps get rid of the most common skin and hair problems.

It works on common skin problems like acne, blemish-prone skin, aging skin, dry skin, etc., and is suitable for all skin types. Frankincense essential oil's anti-inflammatory and antibacterial properties make it beneficial for acne-prone skin. It offers sebum for aged skin and soothes greasy, acne-prone skin. Additionally, it serves as a natural tone, enhances skin tone, and hides pores. It is a strong astringent and works wonders on the skin's wrinkles, fine lines, scars, and stretch marks. Additionally, frankincense essential oil encourages the production of new skin cells, keeps the skin supple, and calms dry, chapped skin[102]

It helps to even out the skin tone by preventing or reducing the occurrence of age spots, sun spots, and other spots. Additionally, it lessens skin inflammation and redness and helps obtain a homogeneous skin tone. It is also used as a treatment for bruises and sore sores. It is a powerful anti-wrinkle and anti-aging agent that treats various skin conditions, including psoriasis and eczema, and helps reduce hair loss, also for suppression of skin and nail infections[19] Moreover, *Boswellia serrata* extracts have been shown to reduce redness and irritation of the skin, act as a soothing agent for sensitive skin and prevent the appearance of red dots after hair removal, and help even skin tone[103](Figure6)

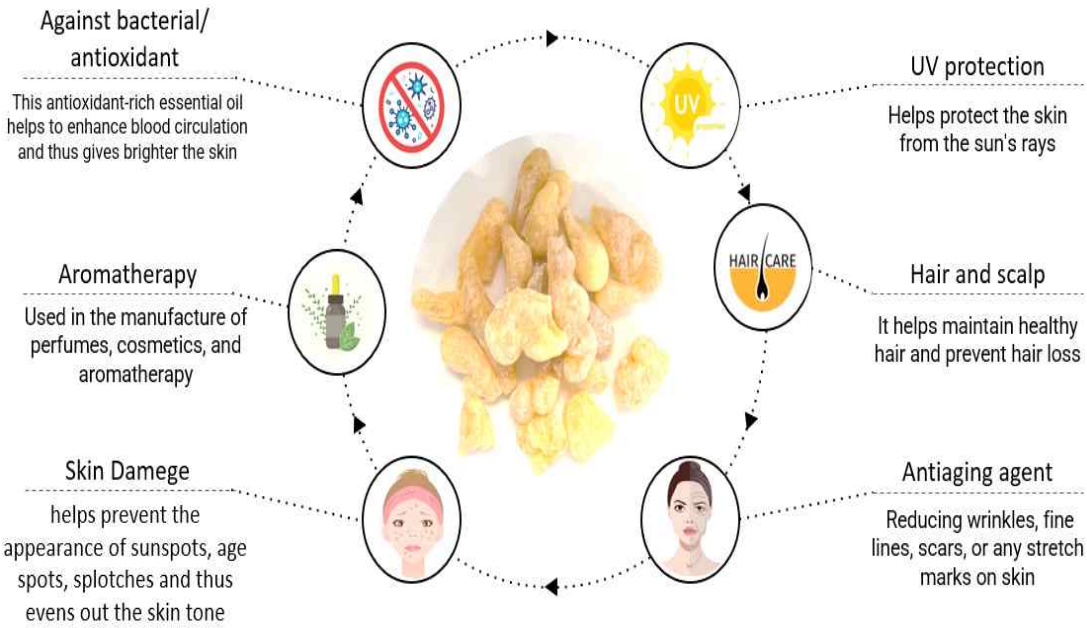


Figure 7. The illustrated list of cosmetic applications of *Boswellia serrata*.

Table 6. Chemical composition of *Boswellia serrata*. resin and use as cosmetic ingredients

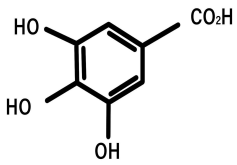
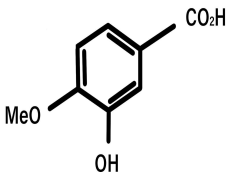
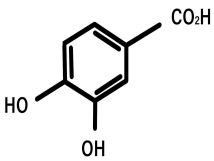
Compound name	Chemical structure	Proof of efficacy as an ingredient in cosmetics	Ref.
Gallic acid		Gallic acid's ability to function as a cosmetic ingredient is complicated by its heat instability. Gallic acid was coupled with a peptide to combat this problem. It was possible to produce galloyl-RGD, a promising candidate for the cosmetic ingredient.	[104, 105]
Vanillic acid		Vanillic acid helps the skin of humans become lighter and less pigmented. Since its skin penetration has been established and the toxicity test has been successful, its use on the skin has expanded.	[106, 107]
Protocatechuic acid		Protocatechuic acid has the capacity to treat skin aging in 8 weeks, according to research results on human skin.	108, 109]

Table 6. (Continued)

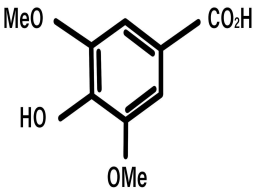
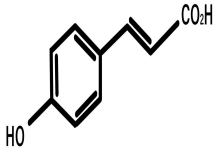
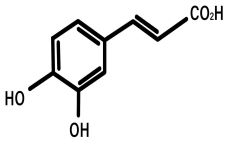
Compound name	Chemical structure	Proof of efficacy as an ingredient in cosmetics	Ref.
Syringic acid		Syringic acid slows down the aging process of cells by blocking ultraviolet B. Syringic acid's effects as an antioxidant and anti-aging agent consequently increased the survival rate of cells damaged by ultraviolet B, suggesting that it can be used as a natural phytochemical in cosmetics.	[110, 111]
Cinnamic acid		Derivatives of cinnamic acid are frequently utilized as UV protection, antioxidant, and antibacterial agents in cosmetic goods.	[112, 113]
Caffeic Acid		Caffeic acids attracted much attention because they are promising and unaffected by free radical toxicity. Due to its antioxidant properties, it is found in cosmetic goods.	[114, 115]

Table 6. (Continued)

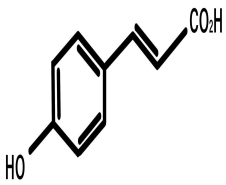
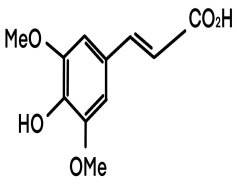
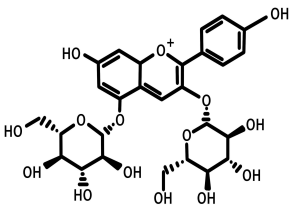
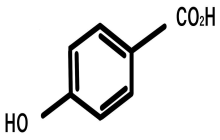
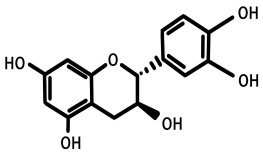
Compound name	Chemical structure	Proof of efficacy as an ingredient in cosmetics	Ref.
Ferulic acid		Ferulic acid is a protein inhibitor that catalyzes the generation of free radicals and enhances the action of scavenger proteins. The primary skin structures are protected by ferulic acid. In addition to enhancing angiogenesis and promoting wound healing, it inhibits melanogenesis. It is typically used to fight photoaging as a skin-brightening component in skincare products.	[116, 117]
Sinapic acid		Sinapic acid protects the skin cell from complete collagen degradation by preventing UVB activation, reducing the in vivo effects of photoaging, and reducing skin tissue inflammation.	[118, 119]

Table 6. (Continued)

Compound name	Chemical structure	Proof of efficacy as an ingredient in cosmetics	Ref.
Pelargonic acid		A fatty acid called pelargonic acid can serve as a surfactant-cleansing agent as well as a fragrance ingredient and emulsifier in cosmetic products. This chemical is safe to use in cosmetic products to improve skin penetration, according to the Cosmetic chemical Review (CIR) Expert Panel's earlier ruling.	[120, 121]
p-Hydroxybenzoic acid		p-hydroxybenzoic acid is utilized in cosmetics to prevent the growth of microorganisms and extend the shelf life of cosmetic and personal care goods.	[122, 123]
Catechin		By crosslinking, catechin can improve collagen arrangement. Studies show that catechin molecules attach to collagen fibers.	[112, 124]

2.2. A review of research on *Boswellia Serrata*

Boswellia Serrata is an excellent plant, serving as medicine and prevention. Due to this, many researchers in the health sciences have focused their attention on figuring out the most effective ways to use this plant to both prevent and treat a variety of ailments. *Boswellia serrata* is a plant with significant medicinal and cosmetic value. Numerous studies, trials, and applications have demonstrated promising therapeutic effects.

a. Toxicity and safety

Boswellia serrata is considered one of the most important frankincense found in the homes of Arabs, Middle Easterners. Families trust this plant for its safe and practical uses. Recent studies demonstrated that boswellic acids and *B. serrata* extract have a significant safety margin.

Boswellia gum resin, which has been used as a medicine for thousands of years, is thought to be secure because it hasn't caused any serious side effects[125] *Boswellia* has remarkably low toxicity, and unlike many chemical anti-inflammatory drugs, its anti-inflammatory effects have no negative impacts on blood pressure, pulse rate, respiration, or other autonomic responses[126] *Boswellia* gum resin has been authorized for use as a food additive by the US Food and Drug Administration (USFDA), and it is included on its list of safe substances[127] The markets are sell over-the-counter anti-inflammatory products that are oral preparations of *B. serrata* extract containing AKBA[127] In previous studies, it was observed that no deaths were noted following a single dosage of *B. serrata* extract administered to mice at a dose of up to 5 g/kg[128] Mice were administered the extract orally for 28 days in a row without showing any behavioral toxicity, and their hepatic and renal function biomarkers did not significantly change as a result[129] *Boswellia* extract was used in animal toxicology tests, and the findings showed that it was safe to use in herbal remedies[76, 130]

b. anti-inflammatory

Boswellia serrata has been shown to be a strong anti-inflammatory medication in both clinical investigations and in-vivo animal models. Boswellic acid inhibits leukotriene production in a dose-dependent manner by acting as a selective, non-redox inhibitor of 5-lipoxygenase. Additionally, it has been shown to reduce levels of leukotriene B4 and 5-hydroxyeicosatetraenoic acid, two active chemotactic agents responsible for increased vascular permeability and pro-inflammatory 5-lipoxygenase products. As a result, less white blood cells are drawn to the area of inflammation, which dampens the inflammatory response and promotes speedier healing when boswellic acid is used as a treatment.

Boswellic acid reduces primary antibody production, polymorphonuclear leukocyte infiltration, and migration and nearly completely inhibits the classical complement system. When boswellic acid was studied in vitro for its impact on the complement system, both the traditional and alternative pathways were significantly inhibited[131]

c. Hypoglycemic

A herbal supplement by modulating hepatic gluconeogenesis, pyruvate carboxylase, and phosphoenol pyruvate carboxykinase, it has been shown to have considerable anti-diabetic activity on non-insulin dependent diabetes mellitus in streptozocin-induced diabetic rats[21]

d. Analgesic and Psychopharmacological activity

Boswellia serrata's non-phenolic fraction exhibits sedative and analgesic properties. Additionally, the potentiated enhanced secobarbitone-induced hypnosis in rats, with no discernible effects on the conditioned avoidance response[21]

e. Muscle Relaxant activity

It was revealed that the essential oil of *B. serrata* has stimulatory effects on skeletal muscles and spasmogenic effects on the smooth muscle of the guinea pig ileum. According to a prior study, the *B. serrata* essential oil operates directly on biological tissues and is not activated by non-specific cell membrane action[21]

f. Anti-Alzheimer's activity

Alzheimer's disease (AD) is a chronic neurological illness. A common and early symptom of AD is increased oxidative stress. Antioxidant-active medicinal plants have long been used to treat various human illnesses. *Boswellia* may be able to treat AlCl3-induced Alzheimer's by increasing Ach levels and lowering AchE activity in brain homogenates, according to the study. A time-dependent improvement in dementia-type AD caused by i.c.v. Streptozotocin injection has also been found to be possible with frankincense[132]

g. Antidepressant activity

The plant's extract is used in a variety of tea blends and as aromatherapy. According to reports, *B. serrata* is effective in treating acute depression. *Boswellia* exhibits strong antidepressant efficacy in acute stress trials and decreases the immobility time in the experimental forced swim model at a dosage of 100 mg/kg. It was discovered that *B. serrata*, a traditionally significant medicinal plant, acts as a bacteriostatic agent[132]

Ⅲ. Materials and Methods

3.1. Experimental Materials and Reagents

3.1.1. Materials

The devices used are a sensitive scale, Autoclave, inoculated Petri dishes, LM2 mill. filter paper (Whatman No. 1), Rotarapor, electromagnetic, vibrating heater, Elisa reader, freeze dryer, different glassware (cups, conical flasks, standard flasks of 500ml capacity), funnels, graduated condensers, glass stem, condenser, thermometer) and distilled water.

3.1.2. Reagents

Reagents used for extraction in this study were ethanol (DUKSAN), methanol (DUKSAN), and ethyl acetate (DUKSAN). For various physiological activity tests, 1,1-Diphenyl-2-picrylhydrazyl (DPPH, SIGMA), L -ascorbic acid (SIGMA), 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS, SIGMA), folin-ciocalteus phenol regent (SIGMA), potassium persulfate (SIGMA), KCl (DUKSAN) , NaCl (DUKSAN), NaCO3 (DUKSAN), Na2HPO4 (DUKSAN), KH2PO4 (DUKSAN), gllic acid (SIGMA), aluminum chloride (SIGMA), potassium acetate (SIGMA), quercetin (SIGMA), kaempferol (SIGMA), isorhamnetin (SIGMA), quercetin dihydrate (WAKO), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (trolox, SIGMA), methanol (THERMO FISHER SCIENTIFIC), phosphoric acid (DUKSAN) and ethanol (THERMO FISHER SCIENTIFIC) were used. All reagents used for HPLC analysis were HPLC grade reagents.

3.2. Extraction and Isolation

3.2.1. Sample collection

The oleo-gum-resin of *B. serrata* used was purchased from the Murshed Market in Dubai, United Arab of Emirates. 500g of resin were collected and shipment to Gwangju Korea Chosun University.

3.2.2. Extractration

3.2.2.1 Soxhlet Extraction

The Soxhlet Extraction was measured by modifying the method of S. Mishra[132] A thimble containing around 5mg of the material was filled before being placed on the Soxhlet extractor. Methanol (100mL) was then added to a distillation flask. The extraction process was done for 6 h. After completing the Soxhlet extraction process, the extract has been set in the concentration device Rotary Evaporator (Eyela N-1100, Shanghai Eyela, China). When the extract dries, should add 40ml of methanol and put it in an Ultrasonic device to combine the extract. Then the extract was divided into several tubes, provided that the content of one tube did not exceed 20ml, and dried by a Centra-Vac (VS-802, Vision, Korea) For up to a day. For the last step, place the extract in Freeze Dryer for a whole day. Calculation of Yield Extract *B. Serrata* 2.72g = 54.4% yielded.

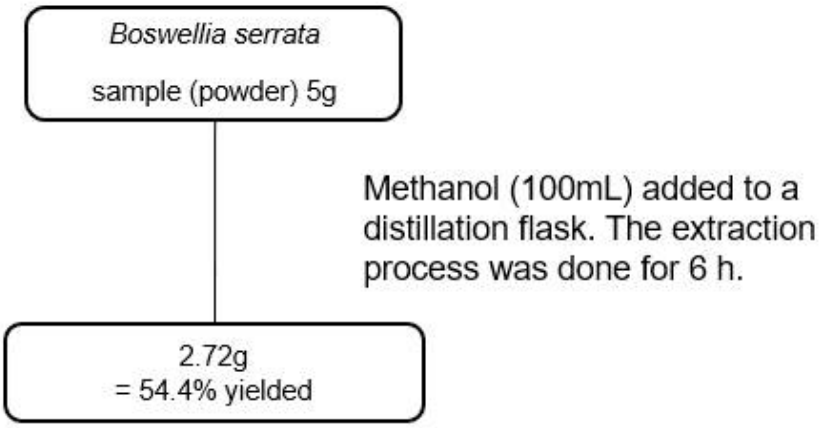


Figure 8. Soxhlet Extraction diagram of *Boswellia Serrata*.

3.2.2.2 Immersion Extraction (70% EtOH)

200g of the sample (powder) was placed in the Ethanol 1400ml / Water 600ml was add to the immersion container. 1 week immersion in mix in room temperature. After completing the immersion process, The extract is filter with paper (Whatman No. 2)After filtering the extract has been set in the vacuum device and a (rotary vacuum concentrator) When the extract dries, should add 90ml of Ethanol \ 10ml of Water and put it in an Ultrasonic device to combine the extract. Then the extract was divided into several tubes, provided that the content of one tube did not exceed 20ml, and dried by a Centra-Vac (VS-802, Vision, Korea) For up to a day. Calculation of Yield Extract *B. Serrata* 59.717g = 29.86% yielded

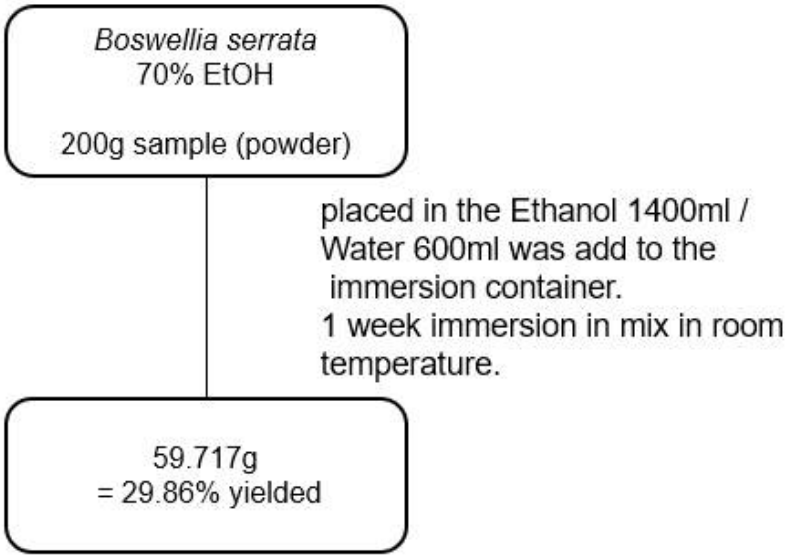


Figure 9. Immersion Extraction diagram of *Boswellia Serrata*.

3.2.3. floor separation

Place 300 mL of the solution (*B.serrata* 70% EtOH 29.36g solvent with 100% MeOH) in a clean separatory funnel and extract with 600 mL of Hexane x3 times then 300 mL of Water with 600 mL of Ethyl acetate x3 times

The separatory funnel should be stopped, Gently shake the funnel and flip it over. Open the stopcock while the funnel is in this position to relieve the internal pressure. Releasing the internal pressure once more after closing the stopcock and giving the funnel a brisk shake This process should be repeated four or five times. Remove the stopper, place the separatory funnel upright in the support ring, and allow it to stand still. Collect the lower aqueous layer of the liquids after they have separated, being cautious not to let any of the top layer leak through the tap. Run the top layer through the separatory funnel's tap and into a different conical beaker.

3.3. Antibacterial activity

3.3.1. Antibacterial agar disc diffusion assay

The Antibacterial agar disc diffusion assay was measured by modifying the method of B. Chand [133] The in vitro antibacterial activity of the *B.Serrata* total crude extract and fractions was evaluated via the disc diffusion method with *S.epidermidis*、*M.furfur*、*M.pachydermatis* and the Anaerobic jar *C.acnes* using Tyrptic Soy Agar(TSA), Modified Leeming Notman Agar(MLNA), Sabouraud Dextrose Agar(SDA), and Reinforced Clostridial Agar(RCA) with determination of inhibition zones diameter measured in millimeter (mm). Sterile filter paper discs (8 mm) were impregnated with Concentration 3mg, 4mg, 5mg of *B. Serrata* extract and then placed on inoculated Petri dishes containing bacterial suspension. Ampicillin disc (10mg) were used as positive control whereas discs without samples (10% DMSO (dimethyl sulfoxide) acted as negative control. The zones of inhibition including the diameter of the extract impregnated dics were compared with those of the controls after incubation. *S. epidermidis* at 37°C for 24h, *M. furfur* at 30~37°C for 3~days, *M. pachydermatis* at 30~37°C for 2~3days and the Anaerobic jar *C. acnes* at 37°C for 3days The inhibition zone diameter (IZD) was used as criteria for the definition of active or inactive sponge extracts. The tests were carried out in triplicate for each extract.

3.4. Antioxidant activity

3.4.1. DPPH free radical scavenging assay

The DPPH radical scavenging ability was measured by modifying the method of HP. Singh [134] Mix 500 μL of 0.123 mM DPPH reagent with 500 μL of each Fraction and each concentration of *Boswellia serrata* resin extract solution (500:500 DPPH) Similarly, each concentration of standard Gallic acid 200 μL : 800 μL was treated with DPPH reagent 0.5 μL to use as positive control, and after reacting in the dark for 15 minutes, Biotek Absorbance, was measured at 517 nm wavelength using Synergy HT multi-detection microplate reader equipment. A comparative experiment was conducted using gallic acid as a positive control group. The radical scavenging ability was calculated by the following equation and expressed as a percentage. Each reaction was measured in triplicate

% of scavenging activity = (A control – A sample) / A control × 100

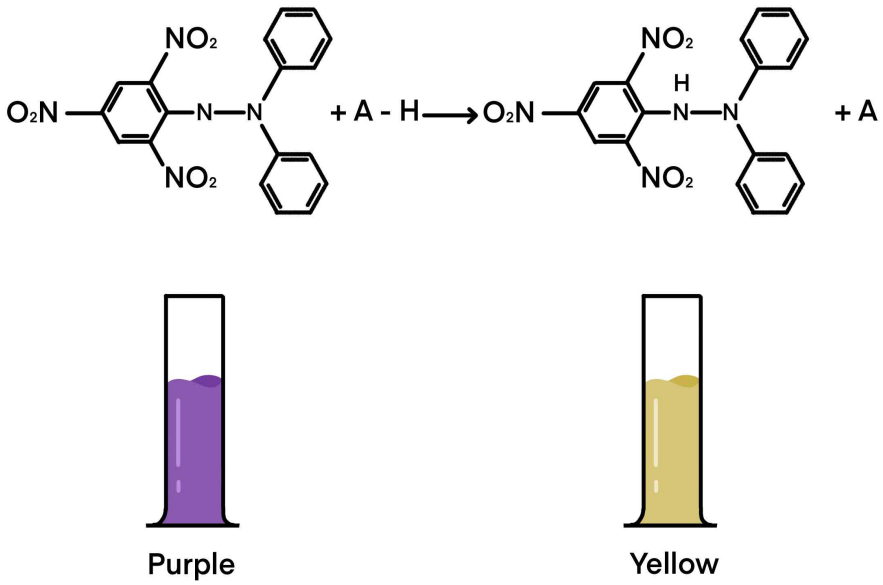


Figure 10. Measurement of the activity of an antioxidant by the DPPH assay.

3.4.2. ABTS radical scavenging assay

ABTS radical scavenging ability was measured by modifying the method of Gupta [135] Prepare 2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS, 14 mM) at a concentration of 7 mM and potassium persulfate (4.9 mM) at a concentration of 2.45 mM to 1: After mixing in a ratio of 1. This solution was diluted with phosphate-buffered saline (0.1 M, pH 7.4), value at 730 After mixing 1,000 μL of ABTS solution with 200 μL of extracts of *Boswellia Serrata* resin extracts for each Fraction and each concentration and reacting for 30 minutes, absorbance was measured at 730 nm wavelength using Biotek Synergy HT multi-detection microplate reader equipment. A comparative experiment was performed using quercetin as a positive control. The radical scavenging ability was calculated by the following formula and expressed as a percentage. Each reaction was measured in triplicate.% of scavenging activity = (A control – A sample) / A control × 100.

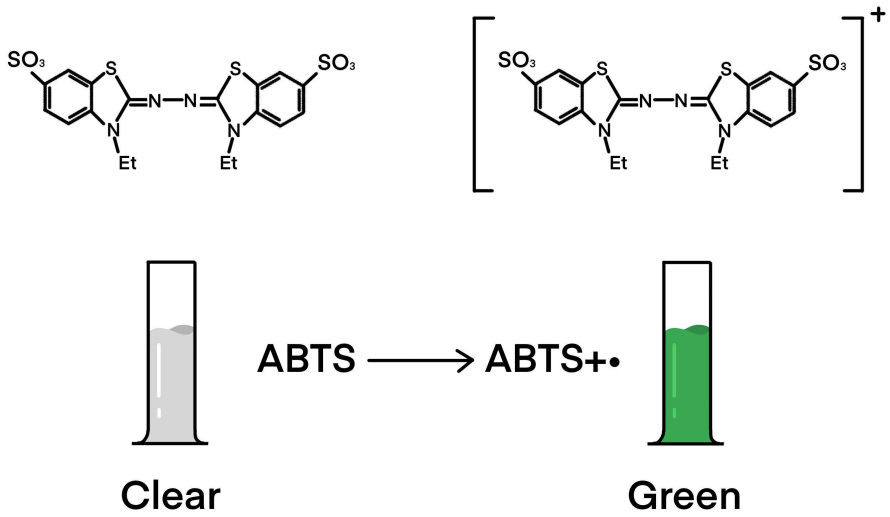


Figure 11. Measurement of the activity of an antioxidant by the ABTS assay.

3.5. Total polyphenol and flavonoid contents

3.5.1. Determination of total polyphenol content

Total polyphenol content was measured by modifying method of MA Ayub [34] 500 μL of 0.2 M Folin-Ciocalteu's phenol reagent and 500 μL of 2% sodium carbonate aqueous solution (w/v) were mixed with 500 μL of extract solution of *Boswellia Serrata* resin for each Fraction and each concentration and reacted for 40 minutes. Absorbance was measured at 750 nm wavelength using Biotek Synergy HT multi-detection microplate reader equipment. The final concentration of the extract was 10 mg/mL, and the total polyphenol content was expressed as gallic acid (GAE) and P-coumaric Acid mg/g equivalent based on the calibration curve.

3.5.2. Determination of total flavonoid content

Total flavonoid content was measured by modifying method of MA Ayub [34] After adding methanol 750 μL, potassium acetate 50 μL, aluminum chloride 50 μL, and ethanol 1.4 mL to 250 μL of extract solution of *Boswellia Serrata* for each Fraction and each concentration, react at room temperature for 40 minutes.

Then Biotek Synergy HT Absorbance was measured at a wavelength of 415 nm using a multi-detection microplate reader. The final concentration of the extract was 500 mg/mL, and the total flavonoid content was expressed as quercetin (QUE) and Rutin mg/g equivalent based on a calibration curve.

3.6. Analysis of polyphenol componds

3.6.1 High performance liquid chromatography (HPLC) analysis

The polyphenols contained in *Boswellia serrata* extracts were quantitatively analyzed by HPLC (SPD-20A, SHIMADZUCO., Japan). Gallic acid, catechin, (-)-epicatechin, vallic acid, narigin, ethyl gallate, p-coumaric acid, ferulic acid, benzoic acid, quercetin, narigenin, kaempferol, and 4-hydroxybenzoic acid were used as polyphenol standards. Standards were tested at a concentration of 100 μg/mL, and extracts were prepared at a concentration of 1,000 μg/mL and filtered through a 0.45 μm syringe filter. The column was analyzed using a Shimpack GIS-ODS (C18, 4.6 × 250 mm, 5.0 μm, Shimadzu Co., Japan) with a flow rate of 1.0 mL/min and an injection volume of 10 μL. The mobile phases were water (A, in 0.1% phosphoric acid) and acetonitrile (B). The gradient conditions of the mobile phase were 0-10 min: B (8-35%), 10-15 min: B (35-35%), 15-25 min: B (35-65%), 25-30 min: B (65-65%), 30-35 min: B (65-100%), 35-40 min: B (100-100%) based on the mobile phase (B), and the wavelength was measured at 280 nm.

3.6.2 HPLC-MS/MS Analysis Method

In order to identify the active ingredients of goldenrod licorice extract, 24 poly-phenols were analyzed by HPLC-MS/MS (AB SCIEX 4000 Q Trap LC/MS/MS System, Shimadzu LC 20A System). A 10 μL aliquot of the sample was analyzed using a C18 column (Gemini 3 μm, C18 110A 50 mm*2.0 mm) at 40°C in a column oven and 15°C in an autosmpler. Anionic and cationic modes were analyzed using Turbo Ion Spray, and water (0.1% formic acid) (A) and acetonitrile (0.1% formic acid) (B) were used as mobile phases. The anionic mode was based on the mobile phase (B): 0-0.5min: B (20-20%), 0.5-2min: B (20-80%), 2-2.5min: B (80-80%), 2.5-2.6min: B (80-20%), 2. 6-6min : B (20-20%) and 0-3min : B (30-30%), and the cationic mode was analyzed as 0-0.2min : B (30-60%), 0.2-2min : B (60-60%), 2-2.1min : B (60-30%), and 2.1-4min : B (30-30%).

Ⅲ. Results and Discussion

4.1. Yield of extract according to Immerion extraction method

The extraction of natural products also shows differences in the extraction yield because the components differ according to the solvent Using Floor separation method.

Extraction yield was obtained by the formula

$$Yield\,(\%) = \frac{Weight\,of\,concentrated\,sample\,after\,extraction\,(g)}{Weight\,of\,Boswellia\,Serrata\,(g)} \times 100$$

The Table summarizes the yield of each Fraction. according to the extracted *Boswellia Serrata,* confirmed that the content of the Hexane Fr. was higher than other Fractions.

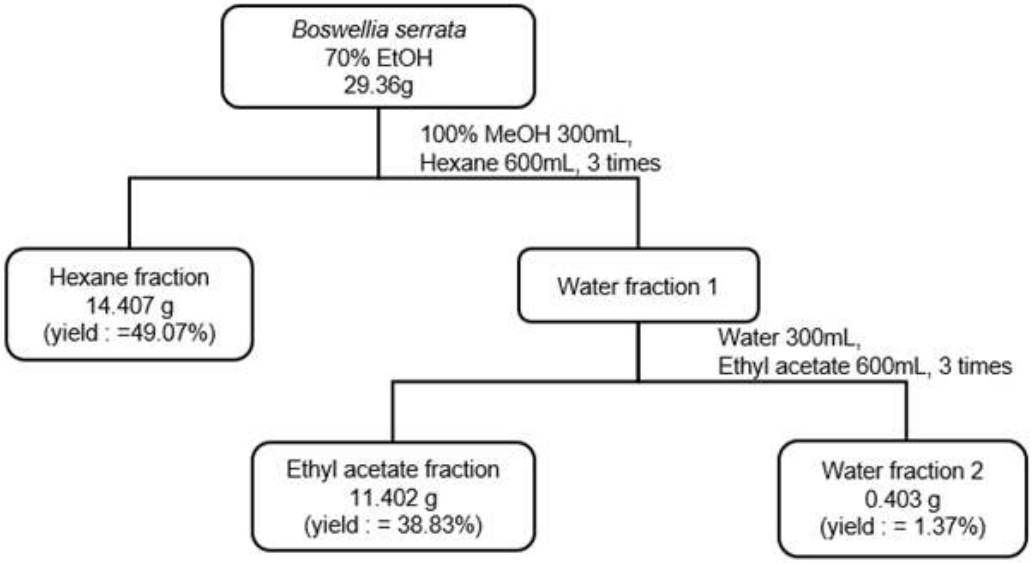


Figure 12. floor separation diagram of *Boswellia Serrata*.

Table 7. The yield of each Fractions according to the extracted *Boswellia Serrata*

Fraction	Total (g)	Yield (%)
Hexane fraction	14.407 g	49.07%
Ethyl acetate fraction	11.402 g	38.83%
Water fraction	0.403 g	1.37%
Oil	0.149 g	0.51%

4.2. Antibacterial activity using well diffusion method

The results of the antibacterial investigations using the well diffusion method are given in Table 5. It indicates that different bacterial species demonstrated different levels of sensitivities towards the tested samples of *B. Serrata* extract. The zone of inhibition of the *B. Serrata* extract in all strains was Antibacterial activity for the corresponding concentrations. The diameter for zone of inhibition for *B. Serrata* extract for *S. epi-dermidis* ranged from 13.3±0.58 to 10.3±0.58 mm, *M. furfur* ranged from 10.6±0.58 to 9±0 mm, *M. pachydermatis* ranged from 13.25±0.35 to 9.75±1.06 mm, and the Anaerobic jar *C. acnes* ranged from 11.83±0.29 to 9.5±0 mm.

In agar well method, the zone of inhibition was larger for all bacteria found to be sensitive than the disk diffusion method.

Table 8. Antibacterial activity of *B. Serrata* using the disk diffusion method

		Inhibition zone (mm)			
sample	conc	*Staphylococcus.epidermidis* (KCTC 3958)	*Cutibacterium.acnes* (KCTC 3314)	*Malassezia.furfur* (KCTC 7743)	*Malassezia.pachydermatis* (KCTC 27587)
Boswellia Serrata	3mg	10.3±0.58	9.5±0	9±0	9.75±1.06
	4mg	11.6±0.58	10.83±0.29	9.75±0.35	11.75±0.35
	5mg	13.3±0.58	11.83±0.29	10.6±0.58	13.25±0.35
AMP	10mg	23±0	40±0	-	-
KTZ	30mg	-	-	34±0	28±0

Legend: AMP=Ampicillin, KTZ=Ketoconazole, - =No Activity

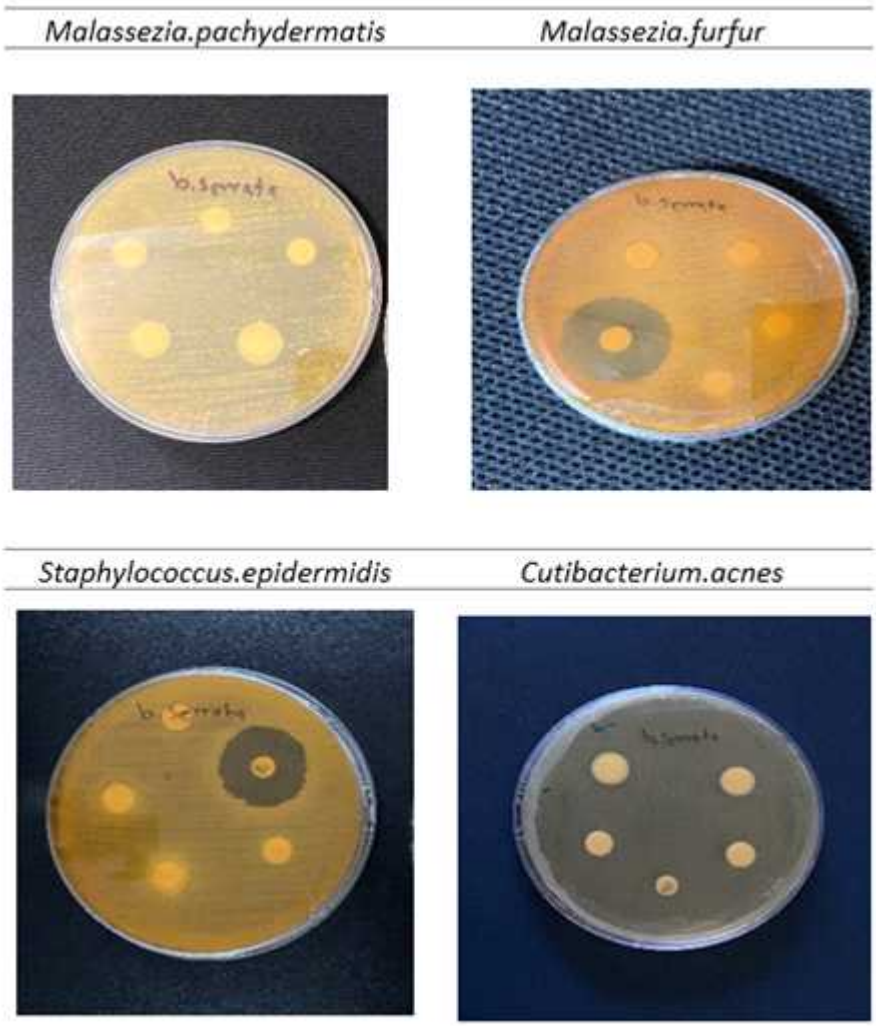


Figure 13. Antibacterial activity of *Boswellia Serrata* of different concentrations against M.*pachydermatis, M.furfur, S.epidermidis,* and *C.acnes* using the disk diffusion method.

4.3. Results of antioxidant activity

4.3.1. DPPH free radical scavenging

Measuring the radical scavenging activity of DPPH is a widely used experimental method because the antioxidant activity of natural products can easily be measured with DPPH, a relatively stable free radical, and is closely related to the actual antioxidant activity. In this experiment, extracts of *Boswellia Serrata* were prepared at a concentration for each Fraction 10 mg/mL – 100 mg/mL 70% EtOH Fr., 5 mg/mL- 30 m g/mL EtOAC Fr., 5 mg/mL – 25 mg/mL Water Fr. to confirm the radical scavenging capacity of DPPH and measured IC50 values. The results are shown in Table 9, As a result of the measurement for each Fractions, it was confirmed that there was higher activity in the Water Fr. compared to the Other fractions, respectively, the Water Fr. showed the highest scavenging activity 902.19 ± 35.53 μg/mL, Ethyl acetate Fr. 20436 ± 652.19 μg/mL ,70% EtOH Fr. 8627.74± 369.22 μg/mL, and the Hexane Fr. Shows No scavenging activity.

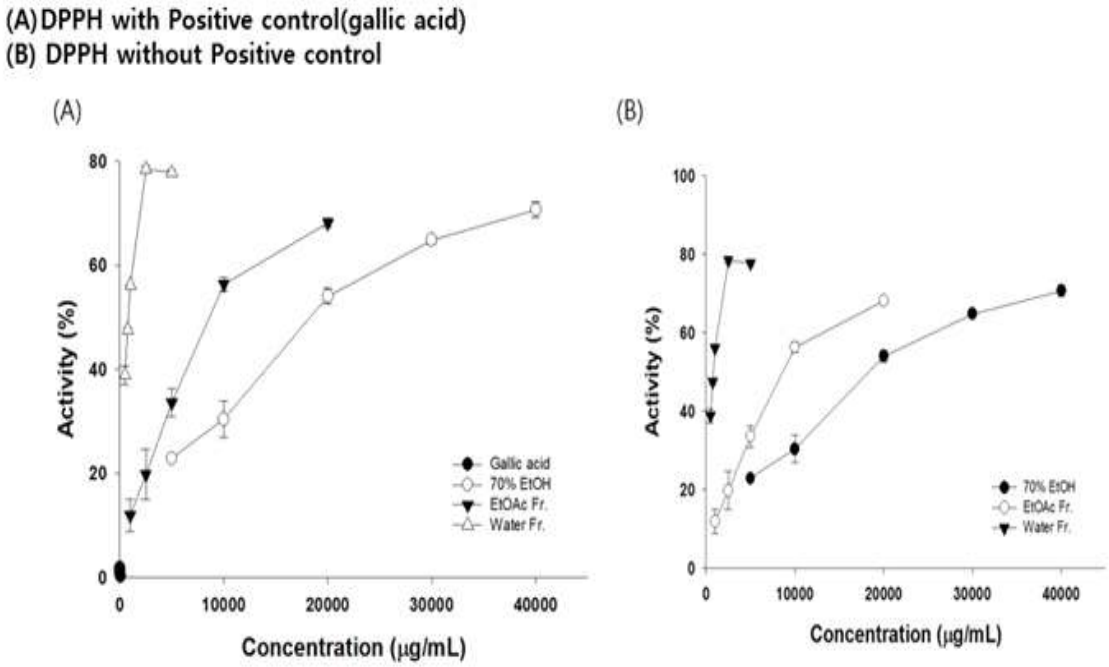


Figure 14. DPPH free radical scavenging activity results of *Boswellia Serrata* extract

4.3.2. ABTS radical scavenging

The root scavenging capacity of ABTS was confirmed by preparing *Boswellia Serrata* extract at a concentration for each Fraction 5 mg/mL – 30 mg/mL 70% EtOH Fr., 5 mg/mL- 30 mg/mL EtOAC Fr., 10 mg/mL – 75 mg/mL Water Fr. and IC50 values were measured. The results are shown in Table 9 As a result of the respectively, which indicated the highest scavenging activity in the Water Fr. it showed a scavenging activity 1845.08 ± 2265.74 μg/mL, Ethyl acetate Fr. 12167.16 ± 8152.82 μg/mL, 70% ethanol Fr.13796.44 ± 660.7 μg/mL, the Hexane Fr. Shows No scavenging activity.

(A) ABTS with Positive control(Quercetin)
(B) ABTS without Positive control

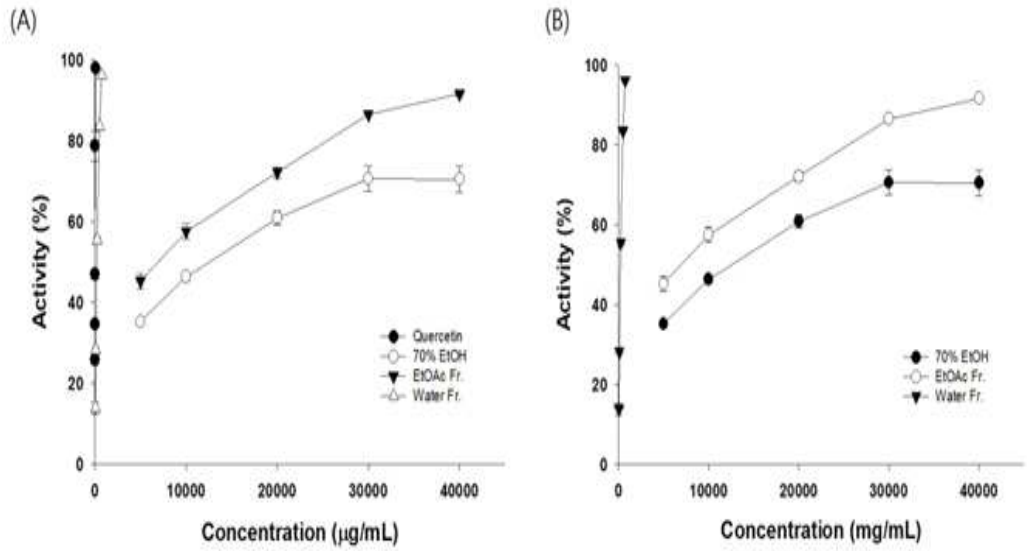


Figure 15. ABTS radical scavenging activity results of *Boswellia Serrata* extract.

4.4. Results of total polyphenol and flavonoid contents

4.4.1 Total polyphenol contents (TPC)

Polyphenol compounds are one of the secondary metabolites widely distributed in the plant kingdom and have different structures and molecular weights. Moreover, they bind easily to proteins and other large molecules due to the phenol hydroxyl group (OH) and are usually used as antioxidants and anticancer agents. Therefore, in this study, the total polyphenol content of *Boswellia Serrata* extract was measured, and the results are shown in Table 9. As a result of the measurement for each Fractions, it confirmed that the polyphenol content in the Water Fr. was the highest, it reached 32.15 ± 0.75 m g/mL, Ethyl acetate Fr. 9.05 ± 0.91 mg/mL, 70% ethanol Fr. 6.54 ± 1.04 mg/mL, and Hexane Fr. reached 5.36 ± 0.16 mg/mL.

4.4.2. Total flavonoid contents (TFC)

Flavonoids are polyphenol compounds, usually including catechin, quercetin, and rutin, the most potent antioxidants. It is found in different plants such as stems, leaves, roots, flowers, and fruits. In this study, the total flavonoid content of *Boswellia Serrata* extracts was measured, and the results are shown in Table 9. It also revealed vast differences in flavonoid contents, with the highest content of flavonoids in Water Fr. 20.29 ± 1.47 mg/mL, Ethyl acetate Fr. 8.81 ± 0.14 mg/mL, 70% ethanol Fr. 6.72 ± 0.71 mg/mL, and Hexane Fr. 3.12 ± 0.14 mg/mL.

Table 9. Radical scavenging activity and polyphenolic/Flavonoids content of different *Boswellia* fractions.

Sample	DPPH IC_{50} (μg/mL)	ABTS IC_{50} (μg/mL)	TPC	TFC
			GAE mg/g	QUE mg/g
70% EtOH Fr.	8627.74± 369.22	13796.44 ± 660.70	6.54 ± 1.04	6.72 ± 0.71
Hexane Fr.	-	-	5.36 ± 0.16	3.12 ± 0.14
EtOAC Fr.	20436 ± 652.19	12167.16 ± 8152.82	9.05 ± 0.91	8.81 ± 0.14
Water Fr.	902.19 ± 35.53	1845.08 ± 2265.74	32.15 ± 0.75	20.29 ± 1.47
STD (Gallic Acid)	23.39 ± 1.91	-	-	-
STD (Quercetin)	-	11.93± 1.16	-	-

IC_{50} = The concentration of compound that affords a 50% reduction in the assay; GAE = gallic acid equivalent. QUE = Quercetine equivalent. - = not detectable.

4.5. Analysis results of polyphenol componds

4.5.1 HPLC Analysis Results

HPLC analysis of *Boswellia serrata* extracts showed that only some of the 13 standards were detected. The water extract was found to have the highest content of gallic acid, while the 70% EtOH extract was found to have the highest content of quercetin. The EtOAc extract was found to have the highest content of epicatechin.

Table 10. Polyphenol compounds identified in Boswellia serrata extracs quantified by HPLC (Unit : μg/mg)

No.	Sample	water	70% EtOH	EtOAc
1	Gallic acid	0.19	0.00	0.00
2	Catechin	0.00	0.00	0.20
3	(-)epicatechin	0.00	0.70	1.01
4	vanillic acid	0.00	0.08	0.18
5	Narigin	0.00	0.14	0.23
6	Ethyl gallate	0.00	0.00	0.00
7	*p*-coumaric acid	0.10	0.07	0.16
8	Ferulic acid	0.00	0.00	0.00
9	Benzoic acid	0.08	0.24	0.64
10	Quercetin	0.01	2.24	0.15
11	Narigenin	0.01	0.04	0.14
12	Kaempferol	0.00	0.00	0.27
13	4-hydroxybenzoic acid	0.00	0.11	0.17
	Total	0.38	3.63	3.16

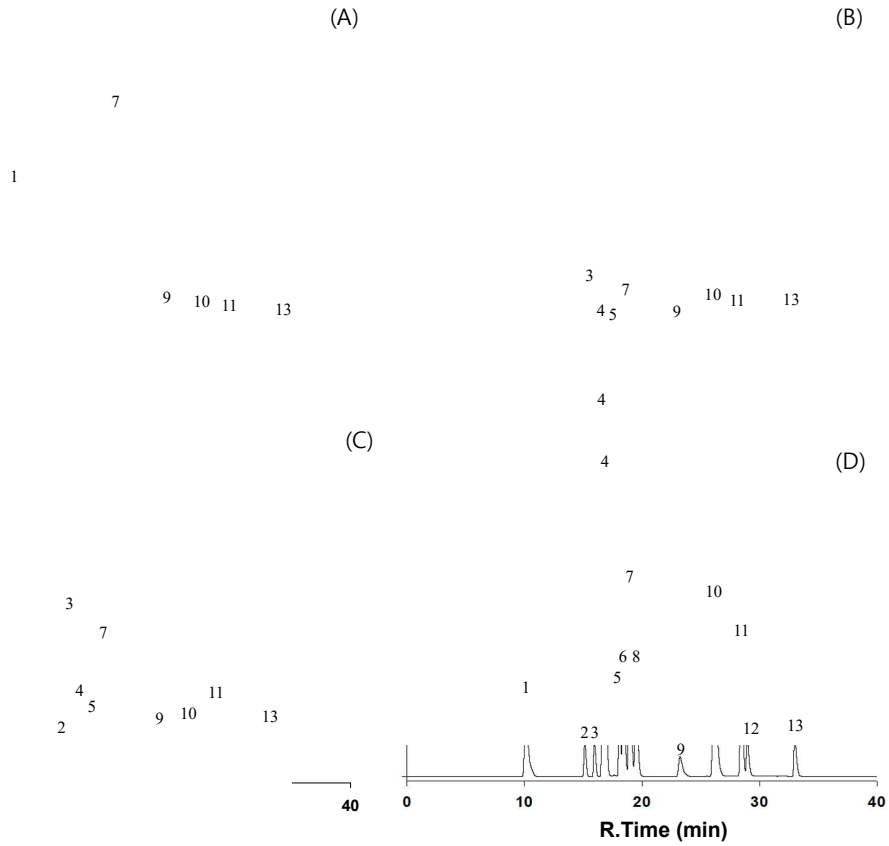


Figure 16. HPLC profile of Boswellia serrata extracts and standard mixture using diode array detection at 280 nm. (A) Boswellia serrata water extract; (B) Boswellia serrata 70% EtOH extract; (C) Boswellia serrata EtOAc extract; (D) standard mixture. Numbers indicate the following: (1) gallic acid; (2) catechin; (3) (-)-epicatechin; (4) vanillic acid; (5)Narigin; (6)Ethyl gallate; (7) p-coumaric; (8) ferulic acid; (9) benzoic acid; (10) quercetin; (11) narigenin; (12) kaempferol; (13) 4-hydroxybenzoic acid

4.5.2 HPLC-MS/MS Analysis Results

A total of 14 polyphenol components were identified by HPLC-MS/MS analysis. The highest content of benzoic acid was found in the 70% EtOH and EtOAc extracts. The highest content of 5-hydroxymethylfurfural was found in the water extract.

Table 11. Polyphenol compounds identified in Boswellia serrata extract quantified by HPLC-MS/MS

No.	Compound	Calculated Concentration (μg/g)		
		Water	70% EtOH	EtOAc
1	4-hydroxy benzoic acid	1.87	0.77	0.64
2	Caffeic acid	0.11	-	-
3	Coumaric acid	0.39	-	0.02
4	Naringein	-	0.01	0.01
5	Benzoic acid	5.45	13.35	6.82
6	Nicotinic acid	0.07	0.06	0.07
7	Gallic acid	-	1.87	1.86
8	Protocatechuic acid	0.26	0.42	0.39
9	Tannic acid	-	0.01	0.01
10	Ethyl gallate	-	0.02	0.02
11	L-Asparagine	0.18	-	-
12	5-hydrox-ymethylfurfural	6.51	3.62	1.92
13	Chlorogenic acid	-	0.40	0.09
14	Quercetin	-	0.06	0.05
	Total	14.84	20.59	11.9

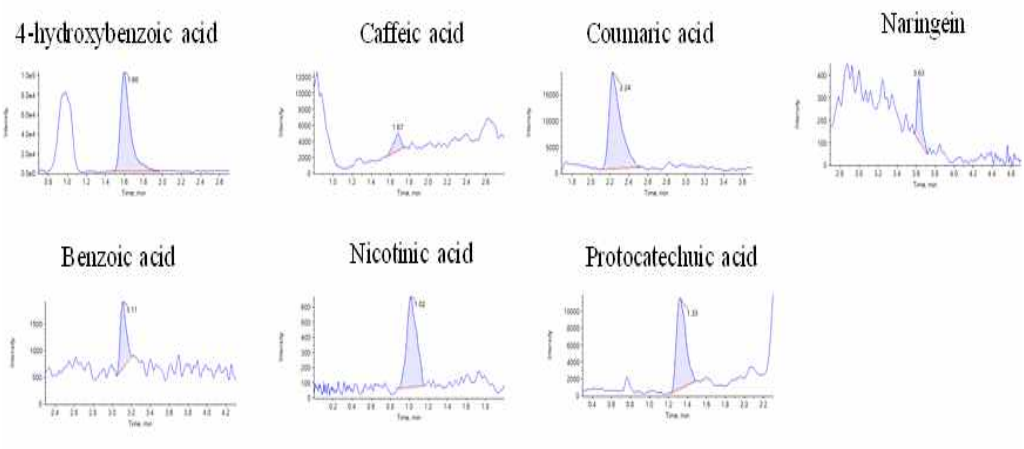


Figure 17. Component analysis of Boswellia serrata water extract by HPLC MS/MS.

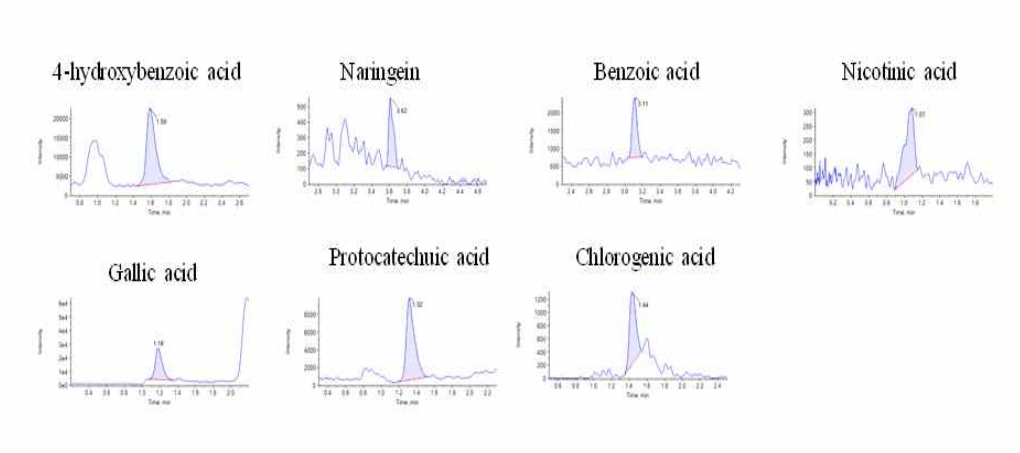


Figure 18. Component analysis of Boswellia serrata 70% EtOH extract by HPLC MS/MS.

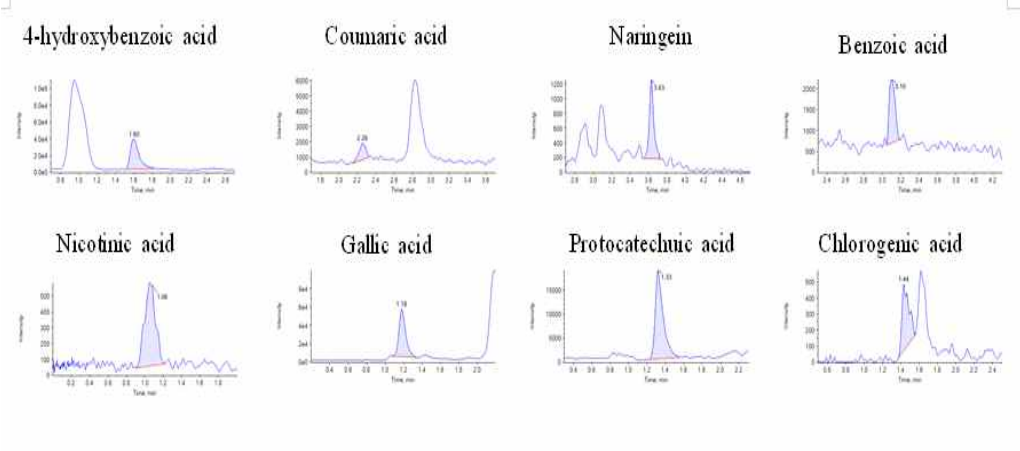


Figure 19. Component analysis of Boswellia serrata EtOAc extract by HPLC MS/MS.

Ⅴ. Discussion

This study highlights the chemical composition and biological activities of *Boswellia serrata* and its influential role as a cosmetic ingredient. The results of previous studies revealed its nutritional, pharmaceutical, and cosmetic benefits as it was used over time.

Boswellia Serrata is a natural source of medicines and cosmetics. It has anti-inflammatory, antibacterial, antioxidant, and anti-irritant properties. They also work on anti-aging, anti-acne, brightening, and calming the skin. In addition, it reduces the consequences of acne and spots. It also works well to prevent hair loss and maintain the health of the scalp and hair[19]

Where the results of the study proved that *Boswellia serrata* possesses effective antibacterial properties, it only shows us the results of Antibacterial activity using well diffusion method

Based on the results shown in Table 5 provides the findings of the well diffusion method-based antimicrobial research. It means that various bacterial species showed varying degrees of sensitivity to the extract of *B. Serrata* samples that were analyzed. The *B. serrata* extract inhibited antibacterial activity in all strains for the relevant concentrations. The diameter of the zone of inhibition for the *B. serrata* extract for *S. epidermidis* ranged from 13.3±0.58 to 10.3±0.58 mm, for *M. furfur* from10.6±0.58 to 9±0 mm, for *M. pachydermatis* from13.25±0.35 to 9.75±1.06 mm, and for *C. acnes* from 11.83±0.29 to 9.5±0 mm in the anaerobic jar.

Boswellia serrata has also been shown to be effective to Radical scavenging activity via diffrent antioxidant assays

Because the antioxidant activity of natural products can be easily measured with DPPH, a relatively stable free radical, measuring the radical scavenging activity of DPPH is a widely used experimental technique. In order to confirm the radical scavenging ability of DPPH and determine the measured IC50 values, extracts of *Boswellia serrata* were produced at a concentration for each fraction of 10 mg/mL – 100 mg/mL 70% EtOH Fr., 5 mg/mL- 30 mg/mL EtOAC Fr., 5 mg/mL – 25 mg/mL

Water Fr.

As a consequence of the measurement for each fraction, the findings are displayed in Table 9. It was confirmed that there was higher activity in the Water Fr. compared to the Other fractions; respectively, the Water Fr. showed the highest scavenging activity 902.19 ± 35.53 μg/mL, Ethyl acetate Fr. 20436 ± 652.19 μg/mL ,70% EtOH Fr. 8627.74± 369.22 μg/mL, and the Hexane Fr. Shows No scavenging activity.

By preparing *Boswellia Serrata* extracts at a concentration for each Fraction, the root scavenging ability of ABTS was verified. concentration for each Fraction 5 ㎎/mL − 30 ㎎/mL 70% EtOH Fr. , 5 ㎎/mL- 30 ㎎/mL EtOAC Fr., 10 ㎎/mL − 75 ㎎/mL Water Fr. IC50 values were measured. Table 9 presents the findings. Accordingly, the Water fraction demonstrated the maximum scavenging activity with a scavenging activity of 1845.08 ± 2265.74 , followed by the ethyl acetate fraction with a scavenging activity of 12167.16 ± 8152.82 μg/mL and the 70% ethanol fraction with a scavenging activity of 13796.44 ± 660.7 μg/mLHexane Fr. Shows No scavenging activity.

In the total polyphenol content of *Boswellia Serrata* extracts was measured, our result of the measurement for each Fraction confirmed that the polyphenol content in the Water Fr. was the highest; it reached 32.15 ± 0.75 ㎎/mL, Ethyl acetate Fr. 9.05 ± 0.91 ㎎/mL, 70% ethanol Fr. 6.54 ± 1.04 ㎎/mL, and Hexane Fr. reached 5.36 ± 0.16 ㎎/mL.

We found that the total flavonoid content of *Boswellia Serrata* extracts also revealed vast differences in flavonoid contents, with the highest content of flavonoids in Water Fr. 20.29 ± 1.47 ㎎/mL, Ethyl acetate Fr. 8.81 ± 0.14 ㎎/mL, 70% ethanol Fr. 6.72 ± 0.71 ㎎/mL, and Hexane Fr. 3.12 ± 0.14 ㎎/mL.

HPLC analysis uses standards to perform qualitative analysis, while LC-MS/MS analysis performs both qualitative and quantitative analysis. Since HPLC analyzes by comparing the retention time with a standard, the peak at the same time may contain multiple substances. LC-MS/MS analysis separates the substances through HPLC, and then each component is analyzed qualitatively and quantitatively through a mass spectrometer. Since it is not a simple separation analysis, after HPLC analysis, LC-MS/MS analysis

is performed for accurate analysis. Therefore, the results of HPLC analysis and LC-MS/MS analysis are bound to be different. In this study, HPLC analysis confirmed that the highest content of gallic acid in the water extract, quercetin in the 70% EtOH extract, and epicatechin in the EtOAc extract were found in the water extract. LC-MSMS analysis confirmed the highest content of 5-hydroxymethylfurfural in the water extract and benzoic acid in the 70% EtOH and EtOAc extracts. The reason for the different analytical results is due to the difference in the analytical methods of the analyzing instruments. In addition, the unknown samples that were not identified in the HPLC analysis require further study and substance identification using analytical instruments other than HPLC-MS/MS.

Ⅵ. Conculusion

Boswellia serrata resin is an important oleo-gum resin used in many industries, including the pharmaceutical, culinary, flavoring, alcoholic beverage, cosmetic, and perfume industries.

It is one of aromatherapy's most commonly used essential oils to treat breathing disorders. It is also used to treat various bacterial and fungal infections.

From the current study, it is concluded that *Boswellia serrata* resin has significant antibacterial and antioxidant activities. As it has proven effective in discouraging bacterial strains that cause skin diseases and grains such a *S.epidermidis*、*M.furfur*、*M.pachydermatis* and *C.acnes*, and it also has the ability to resist free radicals. This means it has many uses and applications in cosmetics, including anti-aging, soothing, and anti-inflammatory properties. It can also encourage faster skin regeneration and increase skin elasticity to lighten the complexion.

Global cosmetic companies have recently relied on manufacturing skin, hair and body care products from natural plant sources. Which means that finding natural sources It is easier to get the most out of these plants when they have cosmetic features and are used in the creation of cosmetics. This also helps to broaden the sources and is likely to reduce environmental losses, such as burning plants and dumping environmental trash. This increases income and contributes to the economic growth of the country exporting these plants.

For future Works Expecting more research to analyze polyphenol componds that were not identified in the HPLC analysis require further study and substance identification using analytical instruments other than HPLC-MS/MS.

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