A Comprehensive Review on the Uses of Camphor (Cinnamomum camphora) in Cosmetic Products with Special Emphasis on Marketed Formulations

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Abstract: The main purpose of this review is to explain how camphor, a natural bicyclic monoterpene ketone, can be used to prevent skin infections. Skin diseases are a group of different conditions that affect the epidermis, dermis, and sometimes deeper tissues, often causing long-term discomfort and reducing quality of life. Many of these conditions are caused by bacteria or fungi, and their treatment is usually difficult and time-consuming.

Therefore, there is a need for natural substances that can both prevent infections and help in skin healing. Camphor is one such compound, known for its anti-inflammatory, antibacterial, antifungal, anti-acne, analgesic, and warming effects. Because of these properties, it can be used in both medical and cosmetic products for preventing and managing skin infections. This review also covers the chemical structure and physical properties of camphor, its natural sources, and methods of extraction and synthesis. In addition, it discusses its industrial applications, metabolism in the body, interactions with other drugs, and its effectiveness against bacteria and fungi, including those that show resistance.

Keywords: camphor; antibacterial activity; antifungal activity; drug resistance; skin infections; wound healing; monoterpenoids; natural compounds

INTRODUCTION

Nowadays, natural substances are becoming more popular in medical treatments. Camphor is one such important compound that belongs to the terpene group. It is obtained from the camphor tree *(Cinnamomum camphora*), which is found in many countries such as Japan, China, Vietnam, Sri Lanka, Africa, Australia, Canada, and the United States(11). The word “camphor” comes from the French term camphre, and it has been used in India since ancient times(12).

Camphor is a white, crystalline substance with a strong smell and a sharp taste. It is mainly extracted from the wood of the camphor laurel tree and other related plants of the laurel family(20). There are two main types of camphor: natural camphor obtained from plants and synthetic camphor prepared chemically. In India, camphor (karpura) is widely used in religious rituals and puja ceremonies because of its pleasant aroma, and its fumes do not irritate the eyes(13).

The camphor tree is large and can grow up to 30–40 meters in height and about 3 meters in diameter. It usually grows in regions located 900–2500 meters above sea level. The bark is yellowish-brown and rough, while the leaves have multiple veins and a characteristic structure(12). The plant has a strong, pleasant fragrance and is also known by other names such as camphor tree, Chinese laurel, and Ravintsara. It is commonly found in moist forest regions, including areas like Madagascar(22).

Camphor is also an important source of essential oil and is used in the production of natural linalool, which is widely used in perfumes and cosmetic products. In addition, natural camphor has been traditionally used in medicines and even in some sweet preparations(13).

Camphor possesses several biological properties, including antibacterial, antiviral, and cough-relieving (antitussive) effects. In modern medicine, it is commonly used in topical preparations such as ointments and balms to relieve minor muscle pain and inflammation. It is also used for its soothing, anti-itch, and anti-infective properties. In some cases, camphor has been used to reduce discomfort such as breast engorgement. Traditionally, it has also been used as a stimulant and to aid digestion (carminative).

Overall, camphor plays an important role in both traditional and modern medicine due to its wide range of therapeutic and cosmetic applications(22).

Biosynthesis of Camphor:

Camphor is formed in plants through a series of biochemical reactions starting from simple precursor molecules. The process begins with geranyl pyrophosphate (GPP), which acts as the main starting compound. During the biosynthesis, GPP is first converted into linaloyl pyrophosphate, which then undergoes a cyclization reaction to form

bornyl pyrophosphate. This compound is further hydrolysed to produce borneol, and finally, borneol is oxidized to form camphor(23).

The formation of GPP itself depends on smaller building units known as C5 precursors. These precursors are produced in plants through two main pathways. The first pathway is the mevalonate pathway (MVA), which occurs in the cytoplasm. The second pathway is the MEP pathway (2-C-methyl-D-erythritol-4-phosphate pathway), also called the DXP pathway, which takes place in plastids. Both of these pathways produce an important molecule called isopentenyl pyrophosphate (IPP). Some of the IPP is then converted into its isomer, dimethylallyl pyrophosphate (DMAPP), by the enzyme isoprenyl diphosphate isomerase. IPP and DMAPP are essential building blocks for the formation of all terpenoid compounds in nature.

By combining IPP and DMAPP in different proportions, plants can form larger molecules such as geranyl pyrophosphate (GPP), farnesyl pyrophosphate (FPP), and other related compounds. Among these, GPP serves as the direct precursor for camphor biosynthesis.

Figure 1 : Camphor

Thus, camphor is ultimately produced through a sequence of enzymatic reactions starting from simple C5 units, leading to the formation of GPP, then borneol, and finally camphor(24).

Chemical Constituents of Camphor:

Camphor is obtained from the plant Cinnamomum camphora, which contains many important chemical compounds. Along with camphor as the main active component, the plant also includes several other natural substances such as menthol, thymol, phenol, salicylic acid, and naphthol. These compounds contribute to its medicinal and therapeutic properties.

The essential oil of Cinnamomum camphora contains various active constituents like camphor, camphene, cineole, dipentene, terpineol, and safrole. Other compounds such as laurolitsine and reticuline are also present in smaller amounts. These chemicals together are responsible for the characteristic smell and biological activities of the plant.

The bark of the plant has a strong, pungent odor due to the presence of compounds like cinnamaldehyde. The leaves also have a strong aroma because they contain eugenol and isoeugenol. Camphor itself is present throughout the plant and plays a major role in giving it its medicinal value.

In addition, the plant contains lignans such as secoisolariciresinol dimethyl ether and kusunokiol, along with other compounds like linalool, terpenol, and volatile oils. The leaf oil is especially rich in linalool, which makes up a large percentage, along with a small amount of citronellal.

However, it is important to note that safrole, one of the components present in the plant, may have harmful effects and is considered potentially carcinogenic.

Overall, the presence of these various chemical constituents makes camphor a valuable natural product with wide applications in medicine, cosmetics, and other industries(26)

Mechanism of Action of Camphor on Skin :

Scientists have studied how camphor works on the skin and found that it has several beneficial effects. It is commonly used in skincare products such as sunscreens, where it acts as a protective agent(31).

Camphor helps in the growth and survival of skin cells called fibroblasts. It activates important pathways in the body (PI3K/AKT and ER pathways), which support cell growth and repair. Because of this, fibroblasts live longer and help in maintaining healthy skin. Camphor also reduces the activity of elastase, an enzyme that breaks down elastin. As a result, the level of elastin increases, improving skin elasticity and reducing signs of aging(32).

It also helps in slowing down skin aging by reducing the activity of beta-galactosidase, a marker of aging cells. Studies have shown that camphor protects skin cells from damage caused by harmful substances like hydrogen peroxide, thereby reducing cell aging. Additionally, camphor prevents excessive thickening of the skin and underlying fat tissues(33).

Camphor acts on different receptors present in the skin, especially temperature-sensitive receptors such as TRPV1, TRPV3, and TRPM8, while inhibiting TRPA1. These receptors are responsible for sensing heat, cold, and pain. Camphor reduces pain by desensitizing TRPV1 receptors and activates

TRPV3 receptors, which are found in skin cells and the nervous system(34,35).

It also affects how the skin senses temperature. After applying camphor, people may feel a cooling sensation followed by warmth. This happens because camphor increases the sensitivity of the skin to temperature changes. It also improves blood circulation in the skin and underlying muscles, which supports healing(36).

In some cases, camphor may cause a mild burning sensation, especially at higher concentrations. It also helps in faster skin repair under certain temperature conditions. After application, camphor can be absorbed through the skin and later excreted from the body through urine(37).

Overall, camphor works on the skin by improving cell function, reducing aging, relieving pain, enhancing blood flow, and providing cooling and warming sensations.

Table : Molecular Effects of camphor on the skin

Molecular Actions of Camphor	Effect	Ref.
Decrease in elastase activity	Increase in the amount of elastin	[32]
Induction of phosphorylation of PI3K/AKT and ER pathways	Inhibition of fibroblast apoptosis	[32]
Action on β-galactosidase	Inhibition of skin aging	[32]
Activation of TRPV1	Desensitizing and analgesic effect	[34]
Activation of TRPM8	Activation of the channel, enhancement of cold sensitivity, inhibition of the response to menthol	[38]
Activation of TRPV3	Heat activation, suggestive sensitizing role	[35]
Activation and inhibition of TRPA1	Agonist–antagonist action, probable role as a cold sensor in nociceptive neurons	[39]

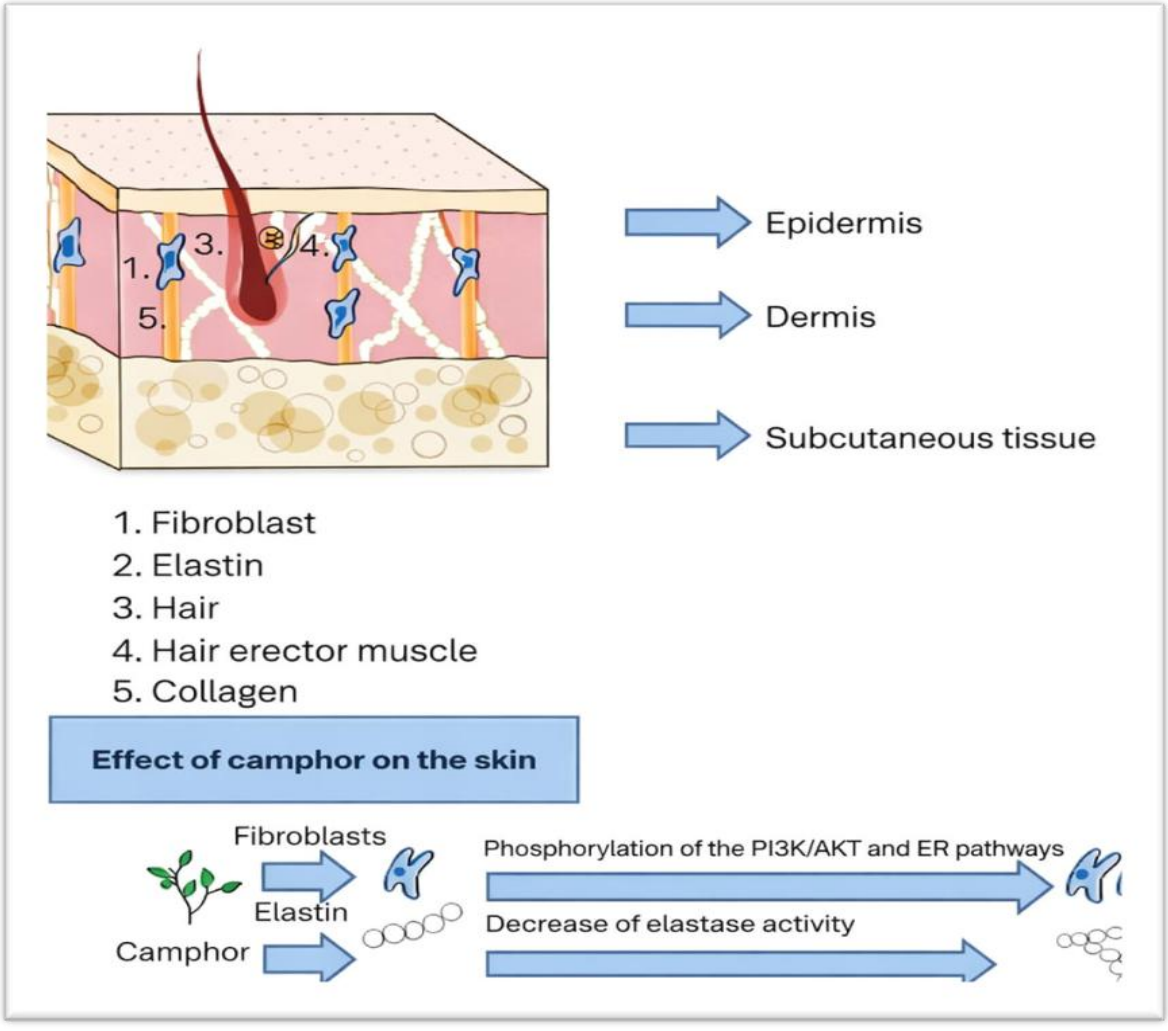

Figure :2 Simplified skin model and camphor effect.

II.METHODS OF TREATING SKIN DISEASES

Essential oils obtained from Cinnamomum camphora are widely used as natural remedies for reducing skin inflammation and soothing irritated skin(40). Camphor plays an important role in improving the penetration of drugs into the skin. It enhances the absorption of medicines through the epidermis without significantly increasing water loss from the skin, which is considered beneficial(41,42).

Studies have shown that camphor can improve the transdermal delivery of several drugs(43). For example, it increases the absorption of drugs like carvedilol, propranolol, and ondansetron when applied along with them. This property makes camphor useful as a penetration enhancer in topical formulations(44).

Camphor is also helpful in managing skin conditions such as atopic dermatitis, as it exhibits anti-inflammatory effects. It works by reducing the production of inflammatory chemicals in the body, thereby decreasing irritation and improving skin condition(45).

In addition, camphor is often used in combination with other natural substances to enhance its therapeutic effects. Mixtures with ingredients like sesame oil and honey have shown faster healing of burn wounds(46). Similarly, combining camphor with certain plant oils has demonstrated improved antimicrobial activity against harmful bacteria (47).

The combination of camphor with menthol is commonly used to relieve itching, as it stimulates specific skin receptors that produce a cooling and soothing sensation. Camphor oil, when used alone or diluted, has also shown effectiveness in treating skin infestations such as scabies and certain parasitic conditions (48).

Camphor derivatives have been studied for treating fungal infections of the skin, showing good results with low chances of recurrence (49). Additionally, camphor is used in some sunscreen products, where it helps protect the skin from harmful UV radiation. Advanced techniques like complex formation are being explored to improve its stability and effectiveness (50).

Some formulations containing camphor, along with other compounds like chondroitin sulfate and glucosamine, have also shown benefits in conditions like joint pain, indicating its broader therapeutic applications (51).

Overall, camphor has multiple benefits in treating skin diseases, mainly due to its anti-inflammatory, antimicrobial, and penetration-enhancing properties. However, its use must be carefully controlled, as high doses or improper use can lead to toxic effects on organs such as the liver, kidneys, and nervous system. In rare cases, it may cause skin irritation or allergic reactions (37,52,53).

Therefore, while camphor is a valuable natural compound in dermatological treatment, further research is needed to develop safer formulations that maximize its benefits while minimizing potential risks (54).

III.USES OF CAMPHOR IN SKIN TREATMENT

Camphor is widely used in the treatment of various skin conditions. It helps in reducing inflammation and irritation and is useful in conditions like acne, eczema, fungal infections, and wounds. It also improves the penetration of other drugs through the skin, making treatments more effective.

Camphor is beneficial in conditions like atopic dermatitis (AD), where it reduces inflammation by controlling the production of certain chemicals (chemokines). It also strengthens the skin barrier and improves moisture retention.

Combination therapies using camphor with other natural substances such as menthol, lavender oil, honey, and sesame oil have shown better results in treating infections and wounds. It is also used in the treatment of itching, scabies, and fungal infections, with good effectiveness.

Additionally, camphor is used in creams, ointments, and gels for pain relief and cooling effects. It also acts as a penetration enhancer, helping drugs like propranolol and ondansetron to enter the skin more effectively.

Safety and Side Effects:
Although camphor has many benefits, it must be used carefully. High doses can be toxic. Oral intake of large amounts may cause serious symptoms such as nausea, vomiting, seizures, and even death.
When applied to the skin, camphor is generally safe in small amounts, but excessive use may cause side effects like redness, itching, swelling, or irritation. In rare cases, long-term use may affect organs such as the liver, kidneys, and nervous system.
Some individuals may also develop allergic reactions, especially when using products containing camphor as a UV filter. Children are more sensitive to camphor toxicity, so it should be used with caution.

Table: Camphor with Herbal Combinations and Their Applications [Ref. 16,17,18,19]

Sr. No.	Category	Combination	Formulation /Product	Uses
1	Skincare	Camphor + Neem	Anti-acne cream, Face pack	Antibacterial, treats acne
2	Skincare	Camphor + Aloe vera	Soothing gel	Burns, pimples, skin irritation
3	Skincare	Camphor + Turmeric	Face mask	Anti-inflammatory, glowing skin
4	Hair Care	Camphor + Coconut oil	Hair oil	Anti-dandruff
5	Hair Care	Camphor + Hibiscus	Hair oil	Promotes hair growth
6	Hair Care	Camphor + Amla	Hair tonic	Strengthens hair
7	Pain Relief	Camphor + Eucalyptus oil	Balm, vapor rub	Relieves pain, cold
8	Pain Relief	Camphor + Clove oil	Massage oil	Muscle pain relief
9	Pain Relief	Camphor + Menthol	Cold balm	Cooling effect, congestion relief
10	Aromatherapy	Camphor + Sandalwood	Incense sticks, dhoop	Spiritual, calming
11	Aromatherapy	Camphor + Rose	Perfume, room freshener	Fragrance, relaxation
12	Aromatherapy	Camphor + Lavender	Diffuser oil	Stress relief, relaxation
13	Insect Repellent	Camphor + Tulsi	Spray, tablets	Mosquito repellent
14	Insect Repellent	Camphor + Lemongrass	Oil	Natural insect repellent
15	Insect Repellent	Camphor + Neem oil	Pest control solution	Kills insects

IV.CONCLUSION AND FUTURE PERSPECTIVES

Camphor (Cinnamomum camphora) is a well-known natural compound that has been used for many years in traditional medicine due to its wide range of therapeutic properties. It has been commonly used to relieve pain, inflammation, skin irritation, and other health problems. Apart from these uses, camphor has also shown benefits in treating conditions like toothache, urinary tract infections, and digestive issues. Its effects are not limited only to physical health, but it may also contribute to mental and emotional well-being. This long history of use highlights its importance as a versatile medicinal agent.

In recent years, scientific research has provided better insight into the biological activities of camphor, including its anti-inflammatory, antimicrobial, and sensory effects. These findings suggest that camphor has great potential for use in modern pharmaceutical and cosmetic formulations. However, to improve its safety and effectiveness, future developments are expected to focus on advanced drug delivery systems such as nano-encapsulation, micelles, transdermal patches, and hydrogels. These technologies can help in controlled release of the drug, improve absorption, and reduce the risk of toxicity.

At the same time, safety remains an important concern, as camphor can be toxic when used in high doses. Therefore, strict safety guidelines and proper dosing are necessary, especially for children. Future research may also explore combination therapies, where camphor is used along with other natural compounds to enhance its therapeutic effects while minimizing side effects.

Despite its promising properties, most of the current evidence is based on laboratory studies, animal experiments, and traditional knowledge. There is a lack of sufficient clinical trials in humans, which limits its direct use in medical practice. Therefore, more well-designed clinical studies are needed to confirm its safety, effectiveness, and proper dosage.

In conclusion, camphor is a biologically active natural compound with significant therapeutic potential. While it shows promising applications in healthcare and cosmetics, further research and clinical validation are essential to establish its role in modern medicine.

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