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Review Article

Exploring Nutritional Phytochemicals in Medicinal Plants for UV Protection

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Abstract

The increasing awareness of the adverse effects of synthetic sunscreens, including skin irritation, environmental toxicity, and potential endocrine disruption, has driven the search for natural alternatives. Plants, being rich sources of bioactive compounds, have emerged as promising candidates for natural photoprotection. Many plant species possess secondary metabolites such as flavonoids, phenolic acids, tannins, and essential oils that exhibit significant ultraviolet (UV) absorption properties, antioxidant activity, and skin-soothing effects. This study explores the potential of various medicinal and cosmetic plants traditionally used for skin care, focusing on their ability to offer sunscreen-protecting activity. Notable examples include Aloe vera, *Camellia sinensis* (green tea), *Curcuma longa* (turmeric), *Ocimum sanctum* (holy basil), *Glycyrrhiza glabra* (licorice), and *Helianthus annuus* (sunflower). These plants not only shield the skin from harmful UVA and UVB rays but also help reduce oxidative stress and inflammation caused by sun exposure. In vitro and in vivo studies have demonstrated that extracts from these plants can significantly enhance the Sun Protection Factor (SPF) when used alone or in combination with conventional sunscreen agents. Additionally, their incorporation into topical formulations supports the development of eco-friendly, biocompatible sunscreens with fewer side effects. Overall, plant-based sunscreens offer a sustainable and skin-friendly alternative to chemical formulations, with growing commercial and therapeutic potential. Further research into extraction methods, compound standardization, and clinical efficacy will pave the way for integrating these botanicals into mainstream photoprotective products.

Keywords: Photoprotectors; Nutritional Phytochemicals; Eco-Friendly; UV Radiation

Introduction

The history of herbal goods mostly started with our earliest ancestors, who discovered that using specific herbs could cure certain illnesses and that other plants might enhance one's appearance; this practice was eventually dubbed cosmetics [1].

One of the most frequent problems facing modern science and cosmetics is protecting the skin from wrinkles and pigmentation changes. These are brought on by UV light, free radical production, and abnormal connective tissue rupture.

Humans are at risk from excessive sun exposure since it has numerous negative consequences on the skin, immune system, and eyes. Numerous outdoor activities have been linked to an increase in skin cancer-related statistics [2].

People are going to the beach wearing only their bathing suits, which increases the risk of sunburn. Experts also claim that avoiding the sun or wearing protective gear can reduce the risk of skin cancer by 80% [3]. According to WHO guidelines, it is imperative to use a generous amount of broader spectrum (SPF 15+) sunscreen after engaging in common outdoor activities including playing, swimming, or working out [4,5]. Blocking UV radiation and improving protection against them are the main objectives of sunscreen formulation [6].

Human health is greatly impacted by sun exposure, which has both advantages and disadvantages. The main natural source of vitamin D production, which is essential for healthy bones and a strong immune system, is moderate sun exposure. Melanogenesis, a natural sunscreen that also has an anti-inflammatory effect on certain skin disorders like eczema, psoriasis, and acne, is increased by sunlight. Additionally, it has been connected to better mood and circadian rhythm management [7,8]. Nevertheless, the hazards of extended or unprotected exposure to ultraviolet (UV) radiation exceed the benefits.

One of the most crucial elements in the existence of life on Earth is solar radiation. In addition, sunlight improves mood, stimulates the synthesis of vitamin D, raises serotonin levels, and has many other positive effects on people. However, the sun can also have negative effects on people, such as causing sunburn, rashes, skin-melanoma, skin cancer, etc., if people are exposed to it too much. This negative effect is caused by several types of radiation. 40% of sunlight is made up of visible light, 50% is made up of infrared energy, and 10% is made up of ultraviolet light. UV A (315-400 nm), UV B (280-315 nm), and UV C are the three categories into which ultraviolet light can be divided [9].

The fundamental units of life are plants. Every living thing on Earth depends on plants. There are many applications and health advantages for plants. In addition to being utilized to treat illnesses, plants are also used to protect our skin. Since the beginning of human history, plants have existed. People have used plants for medicinal purposes from the dawn of time, and for thousands of years, information about herbs has been passed down from one generation to the next (200-280nm) [10,11].

In response to the increased need for natural, safe sun protection in recent years, herbal sunscreens have become a potent alternative. Unlike conventional sunscreens, which are loaded with artificial chemicals, herbal sunscreens protect UV rays using natural minerals and botanical extracts. People with sensitive skin or environmental issues, as well as those who are worried about their health, will find this new trend appealing. Herbal sunscreens frequently contain zinc oxide, titanium dioxide, green tea extracts, aloe vera, cucumber, potato, licorice, and saffron, all of which are well-known for their relaxing and protective properties. Herbal sunscreens are a kinder alternative due to their natural composition, particularly for sensitive skin types. They are therefore desirable to people who are worried about putting.

Numerous bioactive compounds derived from plants are used in cosmetic, pharmaceutical, and food products. Flavonoids are one of the most popular classes; they contain over 8000 identified compounds and are widely known for their anti-inflammatory, anti-cancer, and antioxidant qualities, among other things [12,13]. The flavonols (quercetin, mercetin, rutin, etc.) are among the most well-known subgroups of the flavonoid class [14,15].

Sunscreen serves as the skin's barrier against the damaging effects of direct ultraviolet (UV) radiation and is a photoprotective agent. These days, broad-spectrum sunscreens are being developed to gradually lessen the negative effects of direct UV exposure [16].

People need protection from ultraviolet (UV) radiation, which is why sunscreen products are becoming more and more popular in markets these days [17]. The market for sunscreen products is expected to expand by 5.8% annually, from $13.5 billion in 2020 to $20.1 billion in 2027 [18]. UV radiation can cause skin damage, including sunburns, wrinkles, weakened immunity to infections, early aging, and cancer, which is why there are so many sunscreen lotions on the market [19].

The primary cause of skin cancer is UVB-induced DNA photodamage, which results in mutations in important genes if left untreated. Sunscreens intended to prevent erythema also prevent DNA damage when applied to human skin prior to UVB exposure, according to consistent and convincing experimental.

Mechanism of action

UV-induced photooxidative damage travels via the epidermis to the dermal capillaries, where it depletes the stratum corneum's enzymatic and non-enzymatic antioxidants [21]. Preexisting melanin and its precursors will undergo photooxidation, causing an instantaneous and long-lasting darkening of the pigment. Hemooxygenase, ferritin, glutathione peroxidase, catalase, and other enzymes are also upregulated in response to solar light. UV rays start photooxidative reactions, which in turn trigger reactive oxygen species and protein kinase C. These substances then react with proteins, lipids, and DNA to create cyclobutene pyrimidine dimers, which are the cause of erythema, edema, skin sunburn, and cell death.Additionally, UV radiation activates cytokine and growth factor receptors on the skin's keratinocytes and fibroblasts, changing how cell proliferation is regulated [21].

Herbal substances as absorbents of UV

There are several ways that plants might act as photoprotective agents. The photon's absorption of UV light, followed by the release of less dangerous energy, is one of the mechanisms. The range of compounds present in herbal extracts can absorb visible and UV light of different durations. Plant-based polyphenolic chemicals, flavones, flavonoids, tannins, and lipid fractions have all been shown in several studies to be capable of absorbing UVB and visible light.7 Plant extracts that may operate as natural UV filters include Commiphora mukul, Buddleja cordata, Coffea genus, Crataegus pentagyna, Feijoa sellowiana, Schinus terebinthifolius, Antarctic plants (Deschampsia antarctica, Colobanthus quitensis, Polytrichum juniperinum), and certain lichen species

Aloe- vera

Known for its calming and moisturizing qualities, aloe vera may help strengthen the skin's defenses against UV rays. While Solanum lycopersicum offers significant amounts of lycopene, which is known for its photoprotective properties, Cucumis sativus gives cooling and antioxidant effects. Despite lacking anti-radical qualities, aloe vera demonstrated a remarkable capacity to reduce photodamage both in vitro and in vivo. Remarkably, the preservation of membrane integrity in intracellular organelles and mimetic membranes was linked to the protection that aloe vera provided [22].

Amalaki (*Embellica officinalis*)

In the Indian traditional medical system known as Ayurveda, amalaki (Emblica officinalis) holds a prominent place. Amalaki, sometimes called Phyllanthus emblica or Indian gooseberry, is a member of the Euphorbiaceae family. In Indian traditional medical systems (Ayurveda, Unani, and Siddha), amalaki is one of the most significant medicinal herbs. It is commonly recognized that Amalaki can be used to treat a wide range of illnesses. Fruit is the most crucial component of all. Amalaki fruits boost immunity against illnesses and are frequently used in Ayurvedic preparations. Degenerative diseases like cancer, diabetes, liver disease, ulcers, anemia, eye disorders, and heart problems can all benefit from it [23].

Basil leaves

The ultimate skin and hair savior is holy basil leaves. Additionally, holy basil leaves are a pure Indian herb and a member of the mint family. Remarkably, it was discovered for the first time 5000 years ago. That is to say, it has a divine place in Ayurveda and Hindu mythology. Holy basil leaves actually have potent antioxidants and anti-inflammatory qualities that help treat a variety of illnesses, including the flu, colds, and cough. However, the benefits of basil are not limited to this; in fact, its remarkable beauty benefits primarily address skin and hair problems and, surprisingly, accentuate inherent attractiveness [24].

Carrot seed oil (*Daucus carota*)

The Apiaceae family includes the carrot seed oil daucus carota L., which has 13 subspecies. Of these, one is farmed (D. carota L. ssp. sativus (Hoffm.) Arcang.), while the others are wild. The wild carrot has long been used to treat cancer, prostatitis, gout, cystitis, urinary calculus, and other conditions because to its antilithic, diuretic, carminative, antibacterial, and anti-inflammatory qualities. The cultivated carrot's phytochemical, pharmacological, and therapeutic assessments have been extensively documented in the literature, whereas the wild carrot has received less attention [25].

Coconut oil (*Cocos nucifera*)

A natural component with numerous therapeutic and moisturizing uses is cocos nucifera oil. The items endure longer because of its excellent shelf life and insoluble nature in water. Furthermore,

another moniker for coconut oil that has swept the cosmetics business is Cocos Nucifera Oil. Lauric acid, which is found in cocos nucifera oil, has the power to enhance the texture of skin and hair by deeply [26].

Cucumber (*Cucumis sativus*)

Grown for its crisp, green fruit, cucumbers are a typical vegetable that can climb or spread every year. It is indigenous to the Himalayan region of northern Thailand and belongs to the Cucurbitaceae (gourd) family. Cucumber plants can grow 8 to 18 inches high and 3 to 8 feet wide. If given proper soil and water, cucumber plants can be an incredibly prolific addition to your vegetable garden. Cucumber grows best in full sun and moist, rich, well-drained soil. It prefers a slightly acidic pH. It has high water needs and requires consistent moisture for proper growth, but good drainage is also important. Keep the leaves dry while watering to prevent fungal diseases [27].

Eucalyptus globulus

Eucalyptus Globulus Leaf Oil is a common component of cosmetics and is a volatile oil produced from the fresh leaves of the Eucalyptus, Eucalyptus globulus, and other species of Eucalyptus. This essential oil is well known for its inherent antibacterial and anti-inflammatory qualities and has a clean, energizing aroma. It has a cooling effect and can help relieve skin irritation because it is high in cineole. Because of its ability to support skin that is cleaner and looks healthier, eucalyptus globulus leaf oil is frequently used in skincare products such as cleansers, toners, and lotions. Its potency, however, may cause skin sensitivity in certain people, thus caution is suggested [28].

Fenugreek trigonelline

Hormonal changes, cancer therapies, and genetics all contribute to hair loss, which affects people of all ages and genders. Stress, menopause, pregnancy, and childbirth can all cause temporary hair loss. Due to side effects, current treatments like minoxidil and finasteride have limitations. Minoxidil's effectiveness peaks after a year and then starts to decline, which has led to a quest for natural, plant-based hair growth remedies. The importance of hair for protection, thermoregulation, and sensory perception highlights the necessity of efficient alopecia therapies [29].

Glycyrrhiza glabra (Licorice)

Nature has always provided us with a wealth of medicinal plants that yield important phytochemicals, making it a fantastic source of therapeutic ingredients. Glycyrrhiza glabra, the scientific name for licorice, is a member of the Leguminosae family. One commonly used plant in ayurveda is G. glabra. Both parts of Europe and Asia are home to this therapeutic plant [1]. It is believed that licorice originated in Iraq The most widely distributed species, G. glabra, is found in the Caucasus, western China, Italy, Spain, Turkey, and Central Asia. Conversely, G. uralensis is found throughout Central Asia, which includes China and Mongolia [30].

Grape seed extract (*Vitis vinifera*)

Because of its anti-aging and skin-protective properties, Vitis Vinifera seed extract is a powerful antioxidant that is frequently used in cosmetics. It combats free radicals, which are the cause of premature skin aging and are brought on by pollutants and UV rays. Additionally, it preserves the skin's elasticity and collagen, which keeps it youthful and firm. The liquid form of Vitis Vinifera Seed Extract is usually brown to dark brown and smooth, making it easy to include into various formulations. This extract is a common ingredient in vegan and environmentally friendly cosmetic products because it comes from natural sources. Grape seed extract is another name for Vitis Vinifera seed extract [31].

Henna (*Lawsonia inhermis*)

Ancient and contemporary North African and Asian cultures are closely associated with the usage of Lawsonia inermis L. (henna) for both medical and cosmetic purposes. According to literature and artwork, Lawsonia inermis was utilized for personal decoration and offered psychological and medicinal benefits, playing a significant holistic part in the daily lives of various ancient cultures. Henna has long been used to cure liver and digestive issues, reduce tissue loss in leprosy, diabetic foot illnesses, and ulcers, even though it was originally applied to the hands and feet to guard against fungal pathogens and to the hair to fight lice and dandruff [32].

Hibiscus(*Rosa sinensis*)

A big shrub belonging to the Malvaceae (mallow) family is the Chinese hibiscus. It is indigenous to Asia. When choosing where to plant it, take into account the space it needs because it grows 4 to

10 feet high and 5 to 8 feet broad. This tropical evergreen plant is well-known for its striking flowers, which have a prominent central tube and can reach a diameter of up to 6 inches. The speciesnames Rosa sinensis are Chinese and Latin meaning rose, and the genus name Hibiscus means mallow in Latin.Plant in rich, moist soil that drains well and in an area that receives full sun to partial shade. It is important to keep the roots moist. Chinese hibiscus appreciates high humidity and protection from wind and frost [33].

Jojoba oil

Jojoba oil, or Simmondsia Chinensis seed oil, is a common component in skincare and cosmetics products. It is obtained from the Jojoba plant's (Simmondsia chinensis) seeds. Simmondsia Chinensis Seed Oil is light and non-greasy, with a golden-yellow color. It is a great moisturizer and emollient since it closely mimics the natural oils that the skin produces. This oil is also well known for its capacity to hydrate and nourish the skin by penetrating deeply. To support the health of skin and hair, it is a component in many cosmetic formulas, such as moisturizers, serums, lip balms, and hair care products [34].

Lavender(*Lavandula angustifolia*)

Commonly referred to as lavender oil, Lavandula angustifolia oil is a very powerful substance with relaxing and soothing qualities. Many personal care and cosmetic items contain this clear, colorless to pale yellow liquid, which has a floral, herbaceous scent. Creams, serums, and lotions can benefit from the moisturizing and anti-inflammatory qualities of Lavandula angustifolia oil. In order to encourage hair development and lessen dandruff, it is also utilized in hair care products including shampoos and conditioners. To put it briefly, this chemical has both medicinal and sensory advantages [35].

Lemon balm

The mint family includes the botanical lemon balm (Melissa officinalis). The leaves, which smell slightly of lemon, are used to flavor meals and create medication. Chemicals in lemon balm appear to have a relaxing and sedative effect. Additionally, it may inhibit the growth of certain bacteria and viruses. Lemon balm is used to treat a wide range of ailments, including cold sores, anxiety, tension, insomnia, indigestion, dementia, and many more, however many of these claims lack solid scientific backing [36].

Mango Butter

A natural product made from the seeds of the mango fruit (Mangifera indica) is Mangifera Indica Seed Butter. Because of its nourishing and moisturizing qualities, it is also frequently used in skincare and cosmetic products under the name Mango Seed Butter. Rich in vitamins, antioxidants, and vital fatty acids, mango seed butter helps to soften and hydrate skin. It provides a protective barrier on the skin's surface, limiting moisture loss and creating a smoother and more supple complexion. This component, which adds natural moisture and improves the general health of the skin and hair, is frequently found in body butters, lotions, creams, lip balms, and hair care products [37].

Marigold

Another name for the pot marigold (genus Calendula) is marigold. The original origin of the marigold is currently unknown. However, other studies and the botanical structure point to a Mediterranean origin. Crusaders are believed to have brought the plant to Europe toward the end of the eleventh century. Today, two commercially important calendula-growing regions are Egypt and Hungary.Marigold flowers are found almost everywhere in the world. These flowers grow easily, bloom often, and are less susceptible to insects and diseases [38].

Neem

The neem tree is used to make neem oil. Neem oil is used by some practitioners of Ayurvedic and traditional Chinese medicine to heal ailments like fungal infections and ulcers. Numerous substances found in this kind of oil, such as fatty acids and antioxidants, have skin-benefitting properties [39].

Oat (*Avena sativa*)

The plant's kernels are used to make Avena Sativa Kernel Extract, also referred to as oats extract. Because of its calming and moisturizing qualities, it is frequently used in cosmetics. This extract, which is abundant in bioactive components and natural antioxidants, aids in protecting and nourishing the skin. Avena Sativa Kernel Extract is frequently found in skincare products intended to reduce inflammation, dryness, and irritation. Because of its soft nature, it can be used on fragile and sensitive skin. Because the extract is gluten-free, people who are sensitive to gluten can safely use it. Depending on the formulation, Avena Sativa Kernel Extract usually takes the shape of a light to dark brown liquid or powder [40].

Olive oil

The evergreen tree or shrub Olea europaea L. is the source of Olea Europaea fruit oil. Olea Europaea fruit oil, or simply olive oil, is the fixed oil extracted from the ripe fruit of the olive, Olea europaea l., which belongs to the Oleaceae family. Glycerides of linoleic, oleic, and palmitic acids make up the majority of it. Less dense than water, it is an oily, pale yellow liquid. A wide range of product types, including bath products, bath soaps and detergents, cleansing products, depilatories, makeup, hair conditioners, shampoos, skin care products, shaving products, personal cleanliness products, and suntan products, are made with olive oil and other ingredients derived from it [41].

Pomegranate(*Punica granatum*)

Because of its many advantages, pomegranate extract, also known as Punica Granatum extract, is a natural ingredient that is frequently used in cosmetics. This extract, which is high in antioxidants such polyphenols and anthocyanins, is made from the fruit of the Punica granatum tree. Punica Granatum Extract has the chemical formula C14H16O8. This extract is full of skincare benefits and has a bright, crimson color. By lessening the symptoms of aging, it promotes youthful skin by battling free radicals. Additionally, it has anti-inflammatory qualities that help soothe sensitive skin. Pomegranate extract is a useful component of many skincare and cosmetic products since it also provides benefits like improved hydration, firmness, and a more radiant complexion [42].

Rosa

The rose known as Rosa damascene. The hybrid rose known as Rosa damascena is descended from Rosa fedtschenkoana, Rosa gallica, and Rosa moschata. A deciduous shrub, the Damask rose can grow up to 2.2 meters (7 feet 3 inches) in height. Stiff bristles and strong, curled prickles adorn its stems. Five (sometimes seven) leaflets make up the pinnate leaves. The roses range in color from mild crimson to fairly pink. They are grouped together, the relatively small blooms. The shape of the bush is casual. Because of its prominent place in the pedigree of numerous other varieties, it is regarded as an important Old Rose variety. Because of their delicate scent, the flowers are picked for commercial purposes and used to manufacture rose oil and water, which are used in perfumery. It is considered a notable Old Rose variety due to its prominent position in the pedigree of many other types. The blooms are harvested for commercial usage and used to make rose water and oil, which are utilized in perfumery, due to their subtle fragrance [43].

Raspberry seed oil

An amazing product that is rich in nutrients for the skin and hair is Rubus Idaeus Seed Oil. In addition to combating the obvious symptoms of aging, this emollient shields the skin's surface from the sun's damaging rays. Skin care: High levels of vitamins A and E found in raspberry seed oil moisturize the skin, giving it a smooth texture and a young glow. Additionally, it contains antioxidant, antibacterial, and anti-inflammatory qualities that calm the skin and combat bacteria that cause acne. Because it is lightweight, Rubus Idaeus Seed Oil can be used as a foundation for makeup [44].

Sunflower (*Helianthus annuus*)

The well-known sunflower holds the unique status of being the only extensively grown agricultural species with North American origins. When the plant was first brought to Europe, it was mostly used as an ornamental plant in gardens, even though Native Americans tamed it and bred for plants with single heads and larger seeds. Due in significant part to Eastern Orthodox Church decrees pertaining to Lent diet restrictions, it initially gained popularity as a crop plant in Russia. Consuming oils from many plants (such as olive, palm, and sesame) was prohibited during Lent; however, sunflower, a relatively new crop, was allowed to be consumed at this time and rose to prominence in Russia as an oil crop [45].

Safforn

Because of its antioxidant and skin-brightening qualities, crocus sativus flower extract is a powerful natural ingredient that has gained popularity in the cosmetics sector. In addition to shielding the skin from the sun's damaging rays, it might lessen the production of melanin. Additionally, it is a masking ingredient that prevents a formulation's odor from being detected. The INCI designation for saffron flower extract is Crocus Sativus Flower Extract, which, when uncooked, is a pale yellow liquid. This component is a blessing for the cosmetics industry because it is chemical-free and has several skin-benefitting properties [46].

Terminalia chebula (Haritaki)

Ancient Indian culture is the origin of the 5,000-year-old medical practice known as Ayurveda. Concerns over increasingly invasive, costly, and sometimes harmful mainstream techniques have recently drawn Western medical experts' attention to this extensive collection of healing knowledge, also known as the "Mother of all healing." Around 80% of people worldwide, according to the World Health Organization, primarily rely on plant-based traditional medicine for their basic medical needs.hydrating and promoting their health. As a result, dry skin and hair types benefit from it [47].

Turmeric

Since ancient times, medicinal plants have been utilized, and they are the source of many significant contemporary medications. A common condiment and coloring agent is turmeric (*Curcuma longa* L.). With 8.46 lakh tons produced in 2014-2015, India is the world's biggest producer, exporter, and user of turmeric. The Latin term "terra merita," which meaning meritorious earth, is where the name originates. It has been utilized in traditional medicine and religious practice for at least 6000 years and is also referred to as the "yellow root," "golden spice," and "Indian saffron." Its religious or therapeutic qualities have led to the creation of 55 synonyms in Sanskrit [48].

Wheat germ oil

The oil extracted from the wheat germ or embryo is known as wheat germ oil. About 8% of the kernel's entire weight is made up of the germ. The four primary components of wheat grain are the germ, gluten, endosperm, and bran. About 8% of the weight of wheat comes from the germ, and the remaining 14% comes from the bran [49].

Zingiber officinale (*Ginger*)

Ginger root extract, sometimes called zingiber officinale root extract, is a natural botanical component that is commonly used in skincare and cosmetic goods. This extract, which comes from the rhizome of the Zingiber Officinale plant, is prized for its many skin-benefitting qualities. Packed with anti-inflammatory and antioxidant properties, it helps fight oxidative stress, calm inflamed skin, and lessen redness, all of which contribute to a more balanced complexion. The warming properties of Zingiber Officinale Root Extract help increase blood flow, which can improve the brightness of the skin. It is a useful supplement to treatments meant to renew and rejuvenate the skin because its recipe frequently combines bioactive ingredients including zingerone, gingerol essential oils [50].

Conclusion

Phytochemicals from medicinal plants are essential for natural sun protection and present viable substitutes for artificial UV shields. These bioactive substances, which include tannins, carotenoids, phenolic acids, and flavonoids, have shown strong anti-inflammatory, antioxidant, and UV-absorbing qualities, hence reducing the harmful effects of sunlight. Phytochemicals offer a safer and more environmentally friendly alternative to many chemical sunscreens, which can result in negative responses or damage to the environment. Their vital function in avoiding photoaging, sunburn, and even photocarcinogenesis is highlighted by their capacity to neutralize reactive oxygen species (ROS) and prevent oxidative stress. In the end, using medicinal plants' defensive properties is in line with consumers' increasing desire for eco-friendly and natural skincare products. As studies progress, UV protection based on phytochemicals has enormous potential for both individual health and the health of the environment.

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