Green tea: A Natural Wound Healing Agent

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Abstract

Green tea, made from the leaves of Camellia sinensis, is well-known for its health benefits, thanks to its high levels of antioxidants like catechins, especially epigallocatechingallate (EGCG). Unlike black and oolong teas, green tea is less processed, which helps retain these beneficial compounds. Studies have shown that drinking green tea can improve heart health, lower the risk of cancer, boost brain function, and aid in wound healing and infection prevention. This overview explores the history, classification, chemical makeup, and health benefits of green tea, highlighting its potential as a natural remedy for wound care and skin health.

Keywords: Cameliasinensis, Phytochemistry, traditional uses, skinanatomy, pharmacological activities

Introduction

Tea has a rich history, originating in China and spreading across the globe through various means. Today, it is enjoyed by around 3 billion people worldwide, making it one of the most popular non-alcoholic beverages [1]. Tea classification varies by country, but in China, it is categorized into six main types based on the degree of fermentation: green tea, black tea, white tea, yellow tea, oolong tea, and dark tea [2]. Green tea, the first to be identified, is an unfermented tea known for its "clear brew with green leaves and a strong, astringent flavor." It retains more natural nutrients from the fresh leaves due to minimal vitamin loss during processing.

The main varieties of green tea include Xinyangmaojian, Longjing, Huangshanmaofeng, andBiluochun. Green tea contains several chemical components linked to health benefits, as shown by various studies. Its key components include tea polyphenols, caffeine, theanine, and tea polysaccharides, which exhibit pharmacological effects such as anti-cancer properties[3], antioxidant activity[4], neuroprotection[5], blood sugar regulation[6], anti-inflammatory, and antibacterial effects. Green tea may offer benefits to those with diabetes, arteriosclerosis, coronary heart disease, hypertension, or high cholesterol. However, it's important to note that "natural" does not always mean completely safe, and caution should be taken when consumed by pregnant women, children, and the elderly, despite its generally low risk of side effects.

Tea polyphenols are key to the color and flavor of tea, and are essential for its health benefits[7]. Factors such as species, processing methods, and fermentation levels impact the polyphenol content in tea[8]. Studies analyzing 16 common tea types found that green tea has the highest polyphenol content, suggesting it is the best source for developing tea polyphenol-based functional foods[9]. Camellia sinensis is the plant species from which tea leaves and buds are harvested to produce Chinese tea. This species, belonging to the Camellia genus in the Theaceae family, is used to make white tea, green tea, oolong, and black tea, all processed differently to achieve varying oxidation levels. Kukicha, or twig tea, is also made from Camellia

sinensis but uses the twigs and stems instead of leaves. Common names for the plant include tea plant, tea tree, and tea shrub.

In recent years, numerous studies, both domestic and international, have focused on the chemical composition and pharmacological effects of green tea. However, there is still a lack of systematic and comprehensive reviews of these findings. This paper aims to review the phytochemistry, pharmacological activity, and toxicology of green tea to encourage further research and support the development of green tea resources.

Historical Background

The Camellia species, including over 90 varieties, are found from Nepal to Taiwan and Japan in East Asia. Among these species, the "tea" plant is the most widely spread. Green tea is especially popular in East Asia, particularly in China and Japan, while black tea is the preferred choice in the West. The use of tea leaves dates back over 3,000 years in southwest China, where they were originally chewed and eaten, much like the early use of coffee[10]. In 1835, a wild variety of Camellia sinensis, Assamica, was discovered in India, and later in Thailand and Burma.

Location and Cultivation Areas:

Camellia sinensis, originally from East Asia, Southeast Asia, and the Indian Subcontinent, is now grown globally in tropical and subtropical regions. The plant thrives in warm, sunny climates with a growing season of at least eight months. It experiences three growth spurts, with the most productive period occurring from March to May. Camellia sinensis grows best in sandy loam soils, which allow for good drainage while retaining essential nutrients, and it flourishes in acidic environments[11].

Taxonomic Classification[12] :

Table No. 1: Taxonomic Classification of Green tea

Kingdom	Plantae
Division	Magnoliopsida
Class	Magnoliopsida
Order	Ericales
Family	Theaceae
Genus	Camelia
Species	C.Sinensis
Subspecies	C.sinensisassamica
Varieties	380 and counting

Other Names

Table 2: common name of green tea

Country	Common name
India	Chha
China	Cha
Russia	Chai
Africa	Itye
Italy	Te
England	Tea plant
United state	Tea
Japanese	Ryokucha
Korean	Nokcha

Morphology [13]**:**

- **Leaves**

The leaves are oval-shaped, pointed at the tip, and shiny. They are usually 5–10 cm long and have a finely serrated margin. Young leaves are light green and have short white hairs on the underside, while older leaves are deeper green.

Figure 1: leaves

Uses- weight loss,fabric and paper dye,improving mental alertness,relieving headaches

- **Flowers**

The flowers are white, fragrant, and up to 4 cm in diameter. They have five petals and can occur on their own or in clusters of two to four.

Figure 2: Flower

Uses-detoxifier, diuretic, goodskin, bone health

- **Plant-**

The tea plant is an evergreen shrub or small tree with a strong taproot. It is usually trimmed to below 2 m when cultivated for its leaves.

Figure 3: Plant

Uses- Anti-Aging, Immunity, Burns Fat, Improve Eyesight, Fights of Allergies, Improve Bone Health.

Chemical composition-

Phytochemical studies have shown that green tea contains around 4,000 bioactive compounds. These bioactive compounds are naturally occurring chemicals, known as secondary metabolites, found in plants[14]. The key chemical components of green tea include phenols, alkaloids, flavonoids, tannins, and steroids. Approximately one-third of green tea is composed of polyphenols, which include catechins such as epigallocatechingallate (EGCG), epigallocatechin (EGC), epicatechin-3-gallate, and epicatechin (EC). In addition to polyphenols, green tea also contains flavonoids and their glycosidic derivatives, as well as carotenoids, quinic acid, and chlorogenic acids. Other chemical constituents include methylxanthines, caffeine, lignin, and minerals like manganese and aluminum. EGCG is the most abundant component in green tea and is responsible for many of its pharmacological benefits[15].

Table 3: Principle component of green tea

Components	Green tea (%weight of extraction solid)
Protein	15
Catechin	30-42
Gallic acid	0.5
Ascorbic acid	1-2
Other organic acid	4-5
Minerals	6-8
Methylxanthines	7-9

Skin Anatomy

Skin is the largest organ in the body and covers the body's entire external surface.

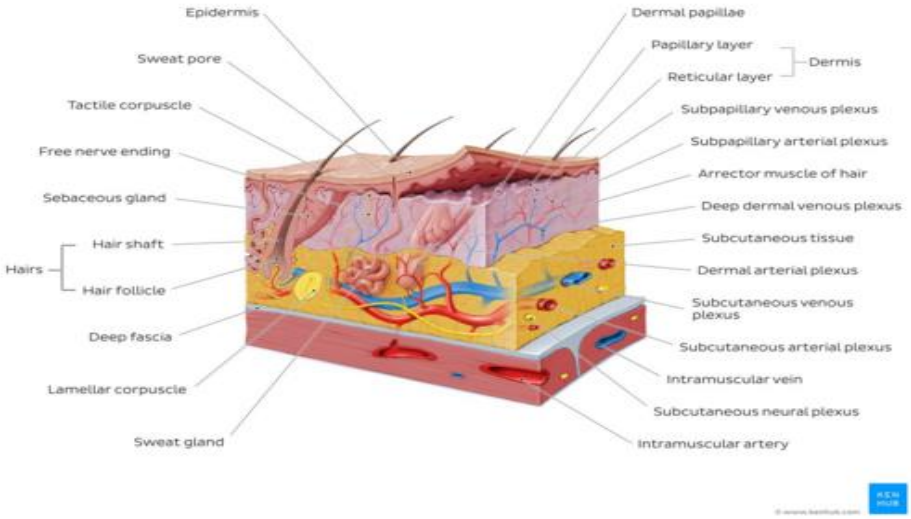

Figure 4: The Integumentary System (Skin)

- The skin is composed of three layers: the epidermis, dermis, and hypodermis.
- This complex structure forms the body’s first line of defense against pathogens, UV light, chemicals, and physical injury. It also plays a key role in regulating body temperature and controlling water loss to the environment.

A skin wound results from the breakdown of the epidermal layer integrity.

- Wound healing primarily refers to the healing of the skin.
- It begins immediately after an injury to the epidermis and can take years to fully complete. This is a dynamic process involving well-coordinated cellular, humoral, and molecular mechanisms.
- The process occurs in three overlapping phases: inflammation, proliferation, and remodeling. Any disruption in these phases can result in abnormal wound healing.

Wound healing stages

Hemostasis Phase- The process of the wound being closed by clotting.

- Happens very quickly.
- Starts whenblood leaks out of the body, then blood vessels constrict to restrict the blood flow.
- The platelets aggregate and adhere to the sub-endothelial surface within seconds of the rupture of a blood vessel's epithelial wall.
- After that, the first fibrin strands begin to adhere in about sixty seconds.
- As the fibrin mesh begins, the blood is transformed from liquid to gel through procoagulants and the release of prothrombin.
- The formation of a thrombus or clot keeps the platelets and blood cells trapped in the wound area.
- The thrombus is generally important in the stages of wound healing but becomes a problem if it detaches from the vessel wall and goes through the circulatory system, possibly causing astroke,pulmonary embolism orheart attack.

Inflammatory Phase

- Begins right after the injury when the injured blood vessels leak transudate (made of water, salt, and protein) causing localized swelling.
- Inflammation both controls bleeding and prevents infection.
- The fluid engorgement allows healing and repair cells to move to the site of the wound.
- During the inflammatory phase, damaged cells, pathogens, andbacteria are removed from the wound area.
- TheWhite blood cells, growth factors, nutrients andenzymes create the swelling, heat, pain and redness commonly seen during this stage of wound healing.
- Inflammation is a natural part of the wound healing process and is only problematic if prolonged or excessive.

Proliferative Phase

When the wound is rebuilt with new tissue made up ofcollagen and extracellular matrix

- The wound contracts as new tissues are built.
- A new network of blood vessels must be constructed so that the granulation tissue can be healthy and receive sufficient oxygen and nutrients.
- Myofibroblasts cause the wound to contract by gripping the wound edges and pulling them together using a mechanism similar to that of smooth muscle cells.
- In healthy stages of wound healing, granulation tissue is pink or red and uneven in texture. Healthy granulation tissue does not bleed easily.
- Dark granulation tissue can be a sign of infection, ischemia, or poor perfusion.
- Finally epithelial cells resurface the injury.
- Epithelialization happens faster when wounds are kept moist and hydrated.
- Generally, when occlusive or semi-occlusive dressings are applied within 48 hours after injury, they will maintain correct tissue humidity to optimize epithelialization.

Maturation Phase (Remodelling Stage)

- Collagen is remodeled from type III to type I and the wound fully closes.
- The cells that had been used to repair the wound but which are no longer needed are removed byapoptosis, or programmed cell death.
- The collagen laid down during the proliferative phase, it is disorganized and the wound is thick.
- Collagen is remodeled into a more organized structure along lines of stress, thereby increasing the tensile strength of the healing tissues. Fibroblasts secrete matrix metalloproteinases. The enzymes facilitate remodeling of type III collagen to type I collagen.
- Generally, remodeling begins about 21 days after an injury and can continue for a year or more.
- Even with cross-linking, healed wound areas continue to be weaker than uninjured skin, generally only having 80% of the tensile strength of unwounded skin.

Pharmacological Actions

Green tea has been extensively studied in people, animals,and laboratory experiments. Results from these studies suggest that green tea may be useful for the following health conditions.

Atherosclerosis

Population-based studies suggest that the antioxidant properties of green tea may help prevent atherosclerosis, particularly coronary artery disease. (Population-based studies refer to research that tracks large groups over time or compares groups from different cultures or with varying dietary habits.) However, in May 2006, the U.S. Food and Drug Administration (FDA) rejected a request from tea manufacturers to label green tea as reducing heart disease risk. The FDA determined that there was no reliable evidence to support health claims that green tea or its extract lowers the risk of heart disease[16-21].

Cancer

Several population-based studies indicate that green tea may help protect against cancer. For instance, cancer rates are generally low in countries like Japan, where green tea consumption is common. However, these studies do not definitively prove that green tea prevents cancer in individuals. Emerging research suggests that the polyphenols found in green tea may play a significant role in cancer prevention, as they are believed to help kill cancer cells and inhibit their progression[22-28].

Ovarian cancer.

Chinese researchers discovered that women who drank at least one cup of green tea daily had higher survival rates compared to those who did not consume it. This study specifically focused on patients with ovarian cancer, and notably, the longest-living individuals were those who drank the most green tea[29-31].

Diabetes

Green tea has traditionally been used to help regulate blood sugar levels. Animal studies suggest that it may aid in preventing the onset of type 1 diabetes and slow its progression once it occurs. In people with type 1 diabetes, the body produces little to no insulin, a hormone that converts glucose and other nutrients into energy. Green tea may assist the body in managing glucose levels[32].

Weight loss

Research suggests that green tea extract may boost metabolism and aid in fat burning. In one study, a combination of green tea and caffeine helped with weight loss and maintenance in overweight and

moderately obese individuals. However, another study found that green tea did not impact weight maintenance after weight loss. The fat-burning properties of green tea are believed to stem from its polyphenols, particularly the catechins found in the tea[33-34].

Antimicrobial Activity

Several studies have indicated that green tea extract possesses antiviral and antibacterial properties. One study found that both water and an ethanolic green tea extract demonstrated antibacterial effects. The research utilized bacterial strains, including *Streptococcus mutans* and *Lactobacillus acidophilus*, isolated from yogurt and dental caries. Green tea extracts inhibited the growth of both strains, showcasing their antibacterial action. Furthermore, green tea effectively inhibits bacteria such as *Salmonella typhi*, *Escherichia coli*, *Staphylococcus aureus*, *Enterococcus*, and *Facalis*.[35]. The polyphenols in green tea disrupt bacterial cell membranes and hinder fatty acid synthesis for the bacterial cell wall, thus preventing bacterial growth[36].

Anti Aging properties:

According to the free radical theory of aging[37], oxidative stress and the increased production of free radicals lead to functional decline and degeneration, including neurodegeneration, caused by phenotypic changes. Imbalances between antioxidants and oxidants are linked to conditions like diabetes, Parkinson's disease, and cardiovascular issues. Green tea helps mitigate oxidative damage to serum lipids and proteins associated with aging. Additionally, it reduces levels of 8-oxo deoxyguanosine (8-oxodG), a marker of oxidative DNA damage, in the liver, kidney, and brain. Thus, the polyphenols in green tea are beneficial in preventing age-related damage to enzymes.

Antioxidant activity:

Green tea, primarily made up of polyphenolic compounds known as catechins, has significant antioxidant activity that is essential for promoting health and preventing disease. The main catechin in green tea, epigallocatechingallate (EGCG), along with othercatechins, plays a key role in this antioxidant effect.

The antioxidant effects of green tea can be understood through several mechanisms. First, catechins act as free radical scavengers. Free radicals are highly reactive molecules that can cause oxidative damage to cellular components such as lipids, proteins, and DNA. By neutralizing these free radicals, green tea polyphenols help reduce oxidative stress, which is associated with various chronic diseases, including cancer and cardiovascular disorders[38].

Additionally, green tea has been shown to decrease lipid peroxidation, a process that harms cell membranes and contributes to the development of atherosclerosis. The catechins in green tea inhibit the oxidation of low-density lipoprotein (LDL) cholesterol, thereby lowering the risk of plaque formation in blood vessels[39].

Moreover, green tea polyphenols can enhance the body's natural antioxidant defenses. They regulate the expression and activity of endogenous antioxidant enzymes like superoxide dismutase (SOD), catalase, and glutathione peroxidase. By boosting the levels of these protective enzymes, green tea further reduces oxidative stress in the body[40].

Clinical studies support these theoretical mechanisms, showing that regular green tea consumption is linked to lower markers of oxidative stress in humans. For example, research has found that green tea extract can

significantly reduce oxidative stress markers and improve overall antioxidant capacity in individuals, contributing to better health outcomes[41].

Angiogenesis Promotion

Angiogenesis is the process of forming new blood vessels, which is essential for growth and healing. However, excessive angiogenesis can lead to issues like cancer. Green tea, particularly its main compound, EGCG, plays a role in regulating this process. EGCG lowers the levels of a protein called VEGF, which signals the body to create new blood vessels. By reducing VEGF, EGCG helps slow down the formation of new blood vessels that tumors require for growth.

In addition, EGCG disrupts signals that keep blood vessel cells alive and reduces inflammation, which often promotes blood vessel growth. It also encourages the death of unwanted blood vessel cells and alters the surrounding environment, making it more difficult for new vessels to form.

Anti-inflammatory Activity-

Green tea is known for its anti-inflammatory benefits, mainly because of a compound called EGCG. This compound helps reduce inflammation by blocking harmful substances and pathways in the body. It also lowers oxidative stress, which can lead to inflammation. Overall, green tea helps manage inflammation and may lower the risk of diseases related to chronic inflammation, promoting better health.[42]

Uses

Culinary Uses:

1. Beverages: Popular in its traditional form as a tea, as well as in iced teas and tea lattes.
2. Food Ingredients: Used in flavoring chocolates, ice creams, and other confections.

Medicinal Uses:

1. Traditional Medicine: Used to treat digestive issues, support cardiovascular health, and manage weight.
2. ModernSupplements:Available in capsules, extracts, and powders for various health benefits.

Cosmetic Uses:

1. Skincare Products : Used in creams and serums for its anti-inflammatory and antioxidant properties, potentially improving skin health and appearance (Kang et al., 2009).

Recent Research and Innovations-

Nanotechnology:

Nanoformulations: Enhancing the bioavailability and stability of green tea polyphenols using nanotechnology, improving their effectiveness in therapeutic applications (Zhou et al., 2021).

Genetic Research:

Personalized Nutrition : Studies show genetic variations affect individual responses to green tea, leading to personalized recommendations for consumption (Kwan et al., 2020).

Sustainability:

Organic Farming : Promoting sustainable and organic farming practices to reduce environmental impact and pesticide use (Mendoza et al., 2019).

Climate Change:

Addressing the effects of climate change on green tea cultivation and developing strategies for adaptation (Gao et al., 2021)

Conclusion

For thousands of years ,medicinal plants have been crucial to human life. green tea has shown promising potential as a natural wound healing agent due to its rich content of polyphenols, particularly epigallocatechingallate (EGCG). These compounds exhibit anti-inflammatory, antioxidant, and antimicrobial properties, which can enhance the healing process and reduce infection risk. While studies support its efficacy, further research is needed to fully understand the mechanisms involved and to establish standardized applications, the taxonomy and morphology of green tea, or Camellia sinensis, highlight its significance as a valuable plant. Belonging to the Theaceae family, it is characterized by glossy, serrated leaves, which are essential for its health-promoting properties. Understanding its classification and physical traits not only aids in the cultivation of high-quality tea but also enhances our appreciation of its medicinal benefits. This foundational knowledge supports ongoing research into the diverse applications of green tea, reinforcing its role as an important natural resource. Overall, incorporating green tea into wound care could offer a complementary approach to traditional treatments, promoting faster and more effective healing.

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