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Topical Applications of Green Tea

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Anti-aging properties of Green Tea by Collagen and Elastin Rebuilding

Anti-aging and anti-acne are one of the major concerns for cosmetics products. Anti-aging and anti-acne properties of green tea by collagen and elastin formation are mentioned in a study. After wrinkle induction using a UVB irradiation for 12 weeks, saline and green tea extracts were applied 200 µl each time, for **four weeks**, five times a week. The green tea treated mice exhibited diminished **epidermal thickness and increased collagen and elastic fiber content**, key signatures for skin restoration. Furthermore, the **reduced expression of MMP-3**, a collagen-degradative enzyme, was observed in the skin of green tea treated animals. At week 4, MMP-3 mRNA expression was significantly decreased by **49%** in the green tea group compared to the control group.

Concentration: 2% (Tea extracts were dissolved in vehicle; propylene glycol: ethanol: water 5 : 3: 2)

Reference: (H. L. Kim et al., 2014)

Facial Sebum/ Pore Enlargement Control by Green Tea

Green tea alone and with other products is utilized for the control of sebum production by face. Elevated sebum production is involved in various skin complications. Any excessive sebum secretion is associated with **pore enlargement** leading to an undesirable pathophysiological condition called acne. A study investigated the efficacy of green tea and green tea plus lotus vs. placebo multiple emulsions in twenty-two healthy adults for controlling casual sebum secretions. Steady and statistically significant reductions in sebum secretions were noted for mono (green tea) and combined (green tea plus lotus) compared to placebo treatment after **60 days** treatment course. In the green tea treated group, significant reduction of the sebum level on the facial skin (about **27% decrease** from baseline) after 60 days of the once-daily application was found. While In the green tea-Lotus treated group significant reduction of the sebum level on the facial skin (**25% decrease** from baseline) after 60 days of the once-daily application was found. This sebum production inhibition activity is associated with active aloe compounds (linoleic acid,

Epigallocatechin gallate) that inhibit various enzymes (5α-R) associated with sebum production.

Concentration: 5% (5% of green tea is used with paraffin oil, Abil EM 90, Magnesium sulfate, and Deionized water for making a simple emulsion of only green tea while 2.5% of green tea and 2.5% of the lotus is used with simple emulsion, Birj 58, Cetomacrogol 1000, HPMC, and Deionized water for making multiple emulsion of green tea and lotus).

Reference: (Tariq Mahmood & Akhtar, 2013)

Green tea Photoprotective effects (healing of sunlight/sunburn/ UV wounds)

Green tea extracts, unlike other sunscreens products, don't only block the radiations, but they provide **healing properties** to sunlight wounds. So, Green tea polyphenolic extracts are used with various topical formulations to provide enhanced photoprotective effects.

A study was conducted to evaluate the effect of polyphenols from green tea on parameters associated with acute UV (ultraviolet radiations found in sunlight) injury. Areas of Skin of normal volunteers were treated with 0.2 mL of green tea polyphenols in concentrations ranging from 1% to 10%. Thirty minutes later, the treated sites were exposed to sunlight radiations to produce erythema (redness of the skin due to skin injury or inflammation). There was a dose-dependent reduction in erythema with a 10% solution producing almost **complete protection/healing** at **48 and 72 hours**. In all subjects, a 2.5% solution was found to provide excellent protection, and in some subjects, even a 0.5% solution was able to produce a significant reduction in the sunburn response. Polyphenolic compounds (Epigallocatechin gallate and Epicatechin-3-gallate) were most efficient at inhibiting erythema. The results also confirmed that these protective results were not because of merely sunscreen effects of green tea, but they were due to the healing properties of green tea.

Concentration: 0.5%, 2.5%, 5%, and 10% (Green tea polyphenols dissolved in water)

Reference: (Elmets et al., 2001)

Acne/ Inflammation treatment by green tea

Acne is a widely occurring **inflammatory** condition that is estimated to affect 40 to 50 million Americans. Green tea is widely used in lotions for the treatment of acne. A study was conducted to determine the efficacy of green tea lotion in mild-to-moderate acne vulgaris. Green tea was given and applied twice daily for six weeks to twenty patients. The mean **total lesion count** (TLC) decreased from 24 before the treatment to 10 after **six weeks of treatment**, a reduction of **58.33%**. The mean **severity index** (SI) decreased from 2.05 before treatment to 1.25 after six weeks of treatment, a decrease of **39.02%**. Topical green tea lotion is an effective, cost-effective treatment for mild-to-moderate acne vulgaris. The adverse effects include the **stinging sensation** in 2 subjects (10%) on the first day of lotion use, disappeared in 48 h, and **minimal pruritus** in 3 of 20 subjects (15%) on the first day of lotion use and lasted three days.

Concentration: 2% (Green tea extracts mixed with vehicle ethanol)

Reference: (Elsaie, Abdelhamid, Elsaaiee, & Emam, 2009)

Moisturizing and Humectant Properties of Green Tea

Green tea is used in several cosmetic products due to its moisturizing property. A study evaluated the skin moisture capacity of green tea on the hairless mouse model. After wrinkle induction using an UVB irradiation for 12 weeks, saline and green tea extracts were applied 200 µl each time, for four weeks, five times a week. The skin moisture capacity of the green tea treatment group was significantly higher compared to the control group throughout the experiment period. At week 4, the **moisture capacity** of the green tea group was **196%**, significantly higher than that of the control group. Overall, the skin transepidermal water loss of green tea treatment group was at the basal levels similar to the normal group in contrast to the control group that displayed a significant increase of skin trans epidermal water loss over time. At **weak 4**, the skin transepidermal **water loss** of the green tea group was **82%** significantly lower than that of the control group.

Concentration: 2% (Tea extracts were dissolved in vehicle; propylene glycol: ethanol: water 5 : 3: 2)

Reference: (H. L. Kim et al., 2014)

Acne Wound Healing Property of Green Tea

A single-blind randomized controlled study investigated the effects of green tea lotion compared to placebo lotion in its ability to decrease acne lesion count. Sixty subjects, aged 14–22 years old (35 women, 25 men) participated in the study for a duration of 2 months between October 2002 and October 2004 in Iraq. The treatment group applied 2% tea lotion twice a day for 2 months, and inflammatory lesion count (papules and pustules) was done at weeks 4 and 8. The control group underwent the same procedure but used a control lotion, which consisted of distilled water. The 2% tea lotion group had a significant decrease in **inflammatory lesion** count at **8 weeks** post-treatment. **Eighty-eight percent** of subjects in the treatment group reported being fully or partially satisfied with the treatment outcome, and 12% were not satisfied. The control group did not have a significant reduction in lesion count at 8 weeks compared to baseline. This study suggests that 2% of tea lotion is an effective topical alternative in acne management. There were no adverse events reported.

Concentration: 2% (75 mL of tea extract with 25 mL of ethanol)

Reference: (Sharquie, Al-Turfi, & Al-Shimary, 2006)

Eczema/Atopic Dermatitis/Itchy and Irritated Skin Treatment by Green Tea

Bath therapy with green tea extract is an effective, safe, and non-steroidal therapy for the treatment of patients with Atopic Dermatitis associated with M. sympodial. A study was conducted to investigate the therapeutic efficacy and safety of bath therapy using green tea extracts for the treatment of patients with **Atopic dermatitis**. Four Subjects underwent treatment with bath therapy using green tea extracts three times per week for a period of **4 weeks**. All patients showed marked improvement on the mean SCORAD (scoring atopic dermatitis) and visual analog scale, and a significant decrease in the mean values of **serum eosinophil counts** was observed after treatment. In general, bath therapy was well tolerated by all patients.

Concentration: 5% (Distilled Green tea juice)

Reference: (H. K. Kim et al., 2012)

Hair Growth Promotion by Green Tea

Green tea extracts are used in various shampoos for enhancement of hair growth. A study was undertaken to measure the effect of epigallocatechin-3-gallate (EGCG) on hair growth in vitro and to investigate its effect on human dermal papilla cells (DPCs) in vivo and in vitro. EGCG promoted **hair growth** in hair follicles vivo culture and the proliferation of cultured **dermal papilla cells**. Similar results were also obtained in vivo dermal papillae of human scalps. Thus, we suggest that EGCG stimulates human hair growth through these dual **proliferative** and **anti-apoptotic** effects on dermal papilla cells. The results appeared in the successive use of EGCG for 4 days.

Concentration: 10% (EGCG in Ethanol vehicle)

Reference: (Kwon et al., 2007)

The wound healing property of green tea

Epigallocatechin-3-O-gallate (EGCG) is a major polyphenolic compound in green tea. It has been known that EGCG regulates the secretion of cytokines and the activation of skin cells during wound healing. In a study, various concentrations of EGCG were added to the electrospun membranes composed of polylactic-coglycolic acid (PLGA), and its healing effects on full-thickness wounds created in nude mice were investigated. The results showed that **cell infiltration** of mice treated with electrospun membranes containing 1 wt% EGCG (1EGCG/PLGA membrane) significantly increased after **2 weeks**. The **re-epithelialization** at the wound site and **formation of blood vessels** also increased in the mice treated with 1EGCG/PLGA membranes in comparison with the mice treated with PLGA membranes. These results suggest that 1EGCG/PLGA can enhance wound healing in full-thickness by accelerating cell infiltration, re-epithelialization, and angiogenesis. The electrospun membranes containing **5 wt%** EGCG (5EGCG/PLGA membrane) exhibited **cytotoxicity** in human dermal fibroblasts (HDFs).

Concentration: 1% (EGCG concentrations mixed with 1% of the total PLGA weight)

Reference: (H. L. Kim et al., 2014)

Increased Skin Smoothness/ Decreased skin roughness, scaling, and Deformation by Green Tea

A study evaluated the green tea skin smoothness effects of cosmetic formulations. Experimental formulations were supplemented or not (vehicle) with green tea leaf extracts (GT). These formulations were applied to the forearm skin of 24 volunteers, and their effects were evaluated before and after 2 hours, 15 and 30 days according to the Skin viscoelastic-to-elastic ratio (skin deformation), and microrelief (roughness, scaling, smoothness, and wrinkling). The skin deformation was significantly enhanced after **30 days** of topical application of the experimental formulation when compared with vehicle and control. The skin viscoelastic-to-elastic ratio results suggest an increase in skin hydration. After **15-30 days**, skin microrelief (**scaling, smoothness, and wrinkling**) was significantly improved due to a reduction in skin roughness. The skin texture parameter considers the portion of **dark spots** that represent skin roughness. The decreased parameter represents an increase in skin surface and texture, suggesting that green tea in cosmetic formulations also improves skin appearance.

Concentration: 6% (6.0% w/w glycolic leaf extract of green tea in formulation-containing 3.0% w/w of a trilaureth-4 phosphate-based blend and 1.0% Sclerotium gum polysaccharid)

Reference: (Gianeti et al., 2013)

Anti-wrinkle Properties of Green Tea

Green tea is used in various creams for the treatment of wrinkles. A study evaluated the anti-wrinkle effects of green tea on a hairless mouse model. After wrinkle induction using an UVB irradiation for 12 weeks, saline and green tea extracts were applied 200 µl each time, for **four weeks**, five times a week. The wrinkle measurement and image analysis of skin replicas indicated that green tea extracts remarkably **inhibited wrinkle formation**. In UV-irradiated animals, green tea extracts greatly improved wrinkle conditions (i.e., **shallow furrows and thin and narrow crests**). The Control group showed a wider wrinkle area than the normal group by 110%, and green tea showed a significantly narrower area of wrinkle than the Control group by **37%**. The data clearly demonstrated that green tea extracts could be used as an effective anti-wrinkle agent in photoaged animal skin, implying their extended uses in therapeutics.

Concentration: 2% (Tea extracts were dissolved in vehicle; propylene glycol: ethanol: water 5 : 3: 2)

Reference: (H. L. Kim et al., 2014)

Anti-aging and Anti-Cancer Properties of Green Tea

The ultraviolet radiation in sunlight causes the production of free radicles, i.e., reactive oxygen species. These free radicles produce the **aging** as well as **cancerous** effects by damaging DNA. Damage to DNA initiates lesions that are necessary for ultraviolet carcinogenesis and aging. Studies to assess the effect of green tea polyphenols on DNA damage were conducted by treating skin with green tea extract and then exposing it to solar light. The extent of **DNA damage** was significantly reduced in **48 hours** by application of Green tea polyphenols before ultraviolet exposure. These effects were due to antioxidant (free radicles scavengers) properties of polyphenol extracts of green tea.

Concentration: 5% (Green tea polyphenols dissolved in water)

Reference: (Elmets et al., 2001)

Green Tea Use in the Treatment of Dandruff, Itching, Hair Loss and Scalp Issues

Green tea has cosmetic benefits that include activities against androgen disorders. A hair tonic containing green tea for the reduction of scalp sebum was developed and clinically evaluated. Stable green tea hair tonics were tested and clinically evaluated in 20 volunteers for 28 days. Hair tonic base with glycerin and butylene glycol (total 4%) gained the highest consumers' preference was incorporated with green tea extract. Green tea hair tonic significantly lowered **scalp** sebum for **21 and 28 days** following the application, suggesting that this topical therapy of scalp greasiness is safe and efficient. The green tea tonic and hair tonic base were able to reduce the **sebum content**, and the **anti oily scalp** efficacy of the green tea hair tonic was **20%** better than the tonic base. Overgrowth of sebaceous glands generates suitable conditions for the proliferation of Malassezia spp. and such conditions should be suppressed accordingly. Scalp and hair disorders such as **itching, dandruff**, and **hair loss** can, therefore, be treated with the proposed green tea hair tonic. All of the products were stable, and none caused skin irritation.

Concentration: 2% (Green tea extracts mixed with hair tonic base)

Reference: (Nualsri, Lourith, & Kanlayavattanakul, 2016)

Skin Hydration, Dry Skin, and pruritus Improvement in Elderly by Green Tea

Dry skin is a major skin health problem in the elderly. The elderly tend to acquire a drier skin; therefore, proper moisturizer usage is necessary to avoid dry skin-related problems, such as **pruritus**. Green tea has recently been used as an active ingredient in moisturizing creams. A study compared the skin hydration effect of green tea and vitamin E moisturizer among 60 elderly. Trained caregivers applied the moisturizer on the participant's right and left forearms, twice a day after showering for **5 weeks**. The green tea moisturizer showed more significant increases in **skin hydration** level than the vitamin E moisturizer at all measurement sites on the right arm and proximal left arm and medial and distal left arm. Skin hydration levels significantly changed over time at proximal, medial and distal right arm, and medial left arm. No side effects were observed during the application period in both groups. Thus routine use of a moisturizer containing green tea may improve skin hydration in the elderly.

Concentration: Green tea moisturizer (Most of these uses 2-5% of green tea)

Reference: (Tjandra, Wijayadi, & Rumawas, 2018)

Long Term Moisturizing Effects of Green Tea against dry skin

A report evaluated the effects of cosmetic formulations containing green tea. Experimental formulations were supplemented or not (vehicle) with green tea leaf extracts (GT). These formulations were applied to the forearm skin of 24 volunteers, and their effects were evaluated before and after 2 hours, 15 and 30 days according to corneum water content, transepidermal water loss, and skin viscoelastic-to-elastic ratio (skin deformation). Experimental formulations (GT) increased skin moisture in the long-term study, indicating that GT has a prolonged moisturizing effect. The skin viscoelastic-to-elastic ratio results suggest an increase in skin hydration that is not limited to the upper cell layers but is also present in the **deeper ones**. This result was probably due to vitamins, proteins, and carbohydrates contained in green tea, which may improve water retention in the stratum corneum.

Concentration: 6% (6.0% w/w glycolic leaf extract of green tea in formulation-containing 3.0% w/w of a trilaureth-4 phosphate-based blend and 1.0% Sclerotium gum polysaccharid)

Reference: (Gianeti, Mercurio, & Maia Campos, 2013)

Skin Roughness, Scaliness, Smoothness, and Wrinkling Treatment by Green Tea

Thirty-three healthy Asian subjects, all men, were enrolled after consent in a placebo-controlled comparative study with split face design. One group applied multiple emulsions with green tea. The second group applied multiple emulsions with lotus extract, while a third group applied a multiple emulsion with a combination of both extracts. In all three groups, active formulations were applied to one side of the face and the placebo to the other side, once daily over the **60-day** treatment course. Non-invasive measurements were performed at baseline and on days 30 and 60. Interesting and significant improvements were observed for the treatment effects on **skin roughness** (SEr), **scaliness** (SEsc), **smoothness** (SEsm), and **wrinkling** (SEw). For example, a **49.99%** improvement in skin smoothness (SEsm) from baseline value and -**23.22%** and perfection in facial wrinkles (SEw) substantiated that combined treatment is superior over single treatments. Green tea and lotus combined in multiple emulsions brought a superior synergistic anti-aging effect. We conclude that diverse anti-oxidant constituents in both plants have a potential influence on skin surface parameters, thus indicating these plants as the future of new anti-aging products.

Concentration: 5% (Green tea alone with water in-oil), 3.75% (Green tea and lotus with water in-oil-in-water)

Reference: (T Mahmood, Akhtar, & Moldovan, 2013)

Chemical Formulation of Fresh Green Tea

(Essential bioactive molecules provided by Green Tea)

Polyphenols 36%: Epicatechin gallate, Epigallocatechin gallate, Epicatechin, Catechin, Epigallocatechin; antioxidant, anti-inflammatory, antimicrobial, and anticarcinogenic properties

Methylxanthines 3.5%: increase metabolic rate and cause fat burning effects.

Amino acids 4%: Theanine unique to tea and decrease anxiety and boost brain activity.

Organic acids 1.5%: Oxalaic, citric, malic, succinic and phosphoric acids.

Carotenoids < 0.1%: Antioxidants

Vitamins 0.27%: A, B, and C (Antioxidant and Nutrient fulfillment)

Volatiles < 0.1%: Flavour

Carbohydrates 25%: Energy, Nutrients, Body Essential Requirements

Protein 15%: Energy, Nutrients, Body Essential Requirements

Lignin 6.5%: Antioxidant

Lipids 2%: Energy, Nutrients, Body Essential Requirements

Chlorophyll, etc. 0.5%: Anticancer, healing

Ash 5%: Minerals

Note. Composition measured in % dry wt.

Reference: (Graham, 1992)

Oral versus Topical administration of Green Tea

The animal studies suggest that oral administration of polyphenolic catechins (GTPPs) can provide skin protection in rodents. However, similar studies in human beings did not achieve such effects, presumably because the human dermis provides a stronger barrier to absorption from the vasculature. Conversely, rodents appear to possess a weaker barrier, in that topical application of polyphenolic catechins (EGCG) at a high concentration (10% in hydrophilic ointment United States Pharmacopeia) resulted in toxicity in mice and formation of erythema and papular lesions within days, but human skin showed no side effects. Therefore, the effects of topical application of polyphenolic catechins (GTPPs), rather than oral administration, may have a greater clinical significance in human beings.

Reference: (Hsu, 2005)

Toxicity of Topical Green Tea

Studies showed that topical green tea tends to be well tolerated. There is no critical toxicity of topical green tea mentioned in literature. Although some minor side effects may be associated with green tea. If any side effect is associated with listed applications of green tea, I have mentioned that side effect in the paragraph of concerned study. Apart from those, I could find these side effects (I think these are also insignificant)

Erythema and Papular Lesion Formation

Female BALB/c mice were dehaired with a topical depilatory and administered 75 µl EGCG in hydrophilic Ointment U.S.P. at three concentrations (10, 3, and 1%, all w/w) daily for 30 days. At the **10% concentration**, gross toxicity was manifested by the formation of **erythema and papular lesions** by day 5. A 7% reduction in weight was observed by day 15. No toxicity was observed at the two lower concentrations or in the vehicle control group. Also, no toxicity was observed when mice were dehaired by shaving. This study was repeated in female SKH1 mice, an outbred hairless strain that does not require depilation. **No toxicity was observed in the SKH1 mice**, indicating that daily topical EGCG appears non-toxic in normal skin. However, the use of topical depilatories may potentiate the dermal toxicity of EGCG. **But human skin is proved as more**

resistant to green tea toxicity, which makes this study less significant for us (Personal comment).

Reference: (Stratton, Bangert, Alberts, & Dorr, 2000)

A study showed a randomized, double-blind clinical trial performed in 60 patients with mild to moderate acne vulgaris. They were randomly divided into two groups and were treated with tea tree oil gel (n=30) or placebo (n=30). They were followed every 15 days for 45 days. In the 5% tea tree oil-treated group, three out of 30 patients (10%) complained of **minimal pruritus**. One patient (3.33%) reported a little **burning sensation** on the application of the drug, and another (3.33%) had **minimal scaling**. In the placebo group, two patients (6.66%) complained of minimal pruritus, and two patients (6.66%) reported a little burning sensation on the application of the drug. **Side effects are also reported by the control group, which makes this study insignificant (Personal comment).**

Reference: (Enshaieh, Jooya, Siadat, & Iraji, 2007)

Tolerability Overall, studies show that topical and systemic tea polyphenols tend to be well tolerated. A study showed minimal side effects to 2% green tea topical. Ten percent of subjects experienced stinging, which resolved within 48 h, and 15% of subjects experienced local pruritus, which resolved by day three.

Reference: (Elsaie et al., 2009)

Loss of Green Tea Phytochemicals due to Processing Method

Temperature/ Alcohol versus Enzymatic Extraction Method

Denaturation and degradation of green tea essential components like catechins, alkaloids, proteins and carbohydrates during the extraction process changes cosmetical and medicinal properties of tea. The extraction method affects the bioactivity of green tea molecules. The quality of green tea extracts depends upon the source, processing, and storage method. Polyphenols are major bioactive molecules of green tea, and they are highly affected by the extraction method.

Why should not use green tea extracts obtained by high temperature?

The high temperature can cause denaturation of polyphenol compounds. At high temperature, the epimerization and degradation of polyphenol compounds are observed in various studies (Komatsu et al., 1993; Liang et al., 2007; Wang, Zhou, & Jiang, 2008; Zheng, Li, Xiang, & Liang, 2016).

Why should we not use green tea extracts obtained by alcohol solvent?

The alcohol (ethanol, methanol) is widely used as a solvent for the extraction of polyphenol compounds. It is observed in various studies that polyphenol compounds of green tea (catechins) are stable at pH lower than 6. As the alcohols possess a pH of 7.3, they contribute to the denaturation of catechins (Ananingsih, Sharma, & Zhou, 2013).

What are the properties of green tea affected by the denaturation of these compounds?

Almost all of the major applications of green tea are affected by any changes in these compounds, such as anti-oxidant, anti-inflammatory, anti-microbial, and anti-carcinogenic (Zink & Traidl-Hoffmann, 2015).

Why should we use extracts obtained by enzymatic method?

Enzyme based extraction provides efficient green tea extracts with less denaturation of phytochemicals. The most distinctive feature of enzymes is that they can effectively operate at mild physiological conditions, atmospheric pressure and pH (Sit, Agrawal, & Deka, 2014).

Green Tea Catechins/ Polyphenols Degradation

Catechins (polyphenols) are the most active and important phytochemicals of green tea. Major of beneficial activities (particularly topical) of green tea is associated with these compounds. So any damage to these compounds would result in serious losses in green application potential. Green tea catechins can undergo degradation, oxidation, epimerization, and polymerization during food processing. Many factors could contribute to the chemical changes of green tea catechins, such as temperature, pH of the system, oxygen availability, the presence of metal ions as well as the ingredients added. These

might affect anti-oxidative, anti-carcinogenic, anti-microbial, anti-viral, anti-inflammatory, and anti-diabetic properties. It is important to understand the stability of green tea catechins in foods during processing and storage in order to gain the optimum health benefits from them. The level of tea catechins could be easily reduced as a result of epimerization and degradation during processing.

Catechins Degradation/ Denaturation by Temperature

Komatsu et al. (1993) reported that the degradation and epimerization of tea catechins could occur simultaneously in thermal processes (Komatsu et al., 1993). Wang, Zhou, and Wen (2006), and Wang, Zhou, and Jiang (2008a) demonstrated that both epimerization and degradation are enhanced by temperature (Wang et al., 2008). Wang et al. (2008a) reported that the concentration of catechins decreased while their isomers increased as the temperature increased. Degradation of catechins was evident as there was a declining trend in total catechins with increasing temperature (Wang et al., 2008).

Catechins Degradation by Alcohol

The stability of tea catechins is pH and temperature-dependent. Tea catechins in aqueous solutions are very stable when pH is below 4, whereas they are unstable in solutions with pH<6. Alcohols have a pH of 7.3; that is why alcohol base processing also causes degradation of catechins.

Reference: (Ananingsih et al., 2013)

Loss of Volatile Compounds due to High-temperature Processing

Green tea processed using leaves stored at low temperatures has higher levels of **volatiles** with floral, fruity, and sweet flavours than that stored at normal or high temperatures. Lipids and fatty acids are important precursors of aromatic volatiles, and the changes in lipid content/fatty acids are related to the volatiles produced in tea. High-temperature processing causes loss in volatile compounds of green tea. The loss of volatile compounds can affect various beneficial properties of green tea, i.e., anti-oxidant potential. The extraction of

green tea polyphenols depends on the various factors, including solubility, pH, extraction time, and temperature.

Reference: (Zheng et al., 2016)

Loss of Caffeine and catechins at 100 °C Processing

When fresh tea leaf was decaffeinated with a ratio of tea leaf to the water of 1:20 (w/v) at 100 °C for 3 min, caffeine concentration was decreased from 23.7 to 4.0 mg g^{-1}, while total tea catechins decreased from 134.5 to 127.6 mg g^{-1}; 83% of caffeine was removed, and 95% of total catechins was retained in the decaffeinated leaf. Caffeine provides many health benefits, such as anti-oxidant activity. Catechins possess anti-oxidant, anti-inflammatory, anti-microbial, and anti-carcinogenic properties.

Reference: (Liang et al., 2007)

Comparison Table

Phytochemicals	Fresh Green Tea (mg/g)	Processed Green tea (High Temperature) (mg/g)	Percentage Decrease %	Affected Application
Chlorophyll a	2.24 ± 0.40	0.14 ± 0.01	93	Anticancer and Antioxidant
Chlorophyll b	0.77 ± 0.065	0.04 ± 0.00	95	Anticancer and Antioxidant
epigallocatechin [EGC]	9.53 ± 0.78	1.22 ± 0.08	87	Antioxidant
epicatechin [EC]	8.91 ± 0.45	6.93 ± 0.72	22	Angiogenesis and vasodilation
epigallocatechin gallate [EGCG]	49.29 ± 1.44	42.95 ± 2.38	13	Antimicrobial, Anti-inflammatory and Anticancer
gallocatechin gallate [GCG]	6.43 ± 0.29	3.61 ± 0.20	44	Lower cholestrol
Total catechins	107.95 ± 3.31	92.53 ± 2.84	14	All Major effects
Moisture content	75.54 ± 0.35	2.04 ± 0.08	98	Moisturizing Effect
Caffeine	23.7	4	83	antioxidant

Reference: (Friedman et al., 2009, Liang et al., 2007, Graham, 1992)

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