Review Article

A Review On: Green Tea: A Miraculous Drink

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ABSTRACT

Green tea is obtained from the plant *Camellia sinensis* belonging to family Theacae. From ancient times tea is drunk worldwide as a beverage in the form of a decoction. It was used to detoxify the body. This attracted many scientists to work on green tea and discover its therapeutic properties. One of them is its Antimicrobial property in curing various infections. Considering this, the present review has been focused on the antimicrobial aspect of green tea. This includes the history of green tea, its pharmacognostical study, chemical constituents, role and mechanism of its main chemical constituent Catechin in curing antimicrobial infections and other ailments. And finally scope of green tea for further research and in designing and formulating drugs of it has been pondered over.

Keywords: Antimicrobial, Catechin, Therapeutic properties.

INTRODUCTION

According to Chinese legend, the history of tea began in 2737 B.C.E. when the Emperor Shen Nong, a skilled ruler and scientist, accidentally discovered tea. While boiling water in the garden, a leaf from an overhanging wild tea tree drifted into his pot. The Emperor enjoyed drinking the infused water so much that he was compelled to research the plant further and discovered tea's medicinal properties. Indian history attributes the discovery of tea to Prince Bodhi-Dharma, an Indian saint who founded the Zen school of Buddhism. Whereas, some cite the Sanjeevani tea plant first recorded reference of tea use in India. However, commercial production of tea in India did not begin until the arrival of the British East India Company, at which point large tracts of land were converted for mass tea production.

India is one of the largest producers of tea in the world, second only to China. Commercial tea plantations were first established under the British Rule when a native variety of *Camellia sinensis* plant was discovered by Scottish traveller Robert Bruce in 1823 in the North-eastern region of India or the present state of Assam.

Figure 1: The discovery of tea in ancient China

Tea derived from leaves of the plant *Camellia sinensis*. It can be categorized into three main types depending on the level of oxidation: green (unfermented), oolong (partially fermented) and black (fermented) tea. It is a refreshing and aromatic drink made from steeping the leaves of Camellia Sinensis in hot water. Tea is the second most consumed beverage in the world after water. More than 75% of all tea produced in this world is black tea, 20% is green and the rest is accounted for by oolongs, whites, and yellow tea.

The synonym of the green tea plant is *Camellia thea* .The biological source of the plant is that it contains the prepared leaves and leaf buds of *Camellia sinesis* or *Thea sinensis* (Linne) O. Kuntze, belonging to family Theaceae (Ternstroemiaceae).

Figure 2: Prepared Green Tea

Figure 3: Green Tea Leaves

Large areas of land are put under cultivation of tea in India Sri Lanka, China, Indonesia and Japan. It is available as black tea from India and Sri Lanka and green tea from China and Japan. Some tea producing regions in India are Darjeeling, Assam, Dooars and Terai, Kangra, Annamalais, Wayanaad, Karnataka, Munnar, Travancore. Black tea is obtained by fermenting the heap of fresh tea leaves and further drying with artificial heat.

Figure 4: Green tea producing areas in the world

The macroscopic characters are as follows**:**

It is a small evergreen shrub when cultivated reaches to the height of 1.0-1.5 meters, while wild growing plants reach up to 6.0 meters. Plant is much branched and bears grey bark. The colours of the leaves are dark green, lanceolate or elliptical, blunt at apex, base is tapering and margin is shortly serrate. Young leaves are hairy while matured leaves are glabrous. Flowers are solitary or in groups of 2 or 3 in the leaf axils, and drooping .The odour of the leaves is characteristics and aromatic and the taste is slightly bitter. The Cultivation and Collection of green tea is not a very tedious process but requires skilled labour and proper conditions for its optimum growth:

- **Conditions of Growth**

  Tea bush is a tropical and sub-tropical plant and thrives well in hot and humid climate. The ideal temperature for its growth is 20°-30°C and temperatures above 35°C and below 10°C are harmful for the bush. It requires 150-300 cm annual rainfall which should be well distributed throughout the year. While prolonged dry spell is harmful for tea, high humidity, heavy dew and morning fog favour rapid development of young leaves. The virgin forest soils rich in humus and iron content are considered to be the best soils for green tea plantations. Relatively large proportion of phosphorus and potash in the soil gives special flavour to tea as is the case in Darjeeling Tea.

- **Method of Cultivation**

  Tea gardens are set up on the cleared hill slopes where shade trees are planted in advance. Seeds are sown in the germination beds and the saplings transplanted to the garden. The garden is regularly hoed and weeded so that tea bush grows without any hindrance. Use of manures and fertilizers is a common practice in the gardens. Oil cakes and green manures are widely used. Pruning of the plant is an essential part of tea cultivation. It helps in maintaining the proper shape of tea bush to a height of about one metre with about the same diameter.

- **Preparation of Green Tea**

  It is prepared by exposing the freshly collected leaves to the air until most of the moisture is removed. Then they are roasted and stirred continuously until leaves become moist and flaccid. Then they are passed to rolling table and rolled into balls and subjected to a pressure which removes the moisture. Then the leaves are shaken out on the copper pans and roasted again till the leaves assume dull green colour. Then the leaves are winnowed, screened and graded into various varieties.

Figure 5: Overall process of tea manufacturing

Figure 6: Cultivation of Green Tea

Green tea has a wide variety of uses. It is useful as a CNS stimulant in the form of beverage besides, it is a diuretic as well, soothe sunburns, soothe tired eyes, soothe blisters, soothe bleeding gums, cure the common cold, it acts as a sterilizing agent for many types of bacteria that cause food poisoning. The tea plant contains natural fluorine and the catechin glucosyl transferase which stops cavities, destroying the cariogenic bacteria that cause plaque and oral bacteria which produce bad breath, it effectively inhibits the abnormal formation of blood clots (thrombosis), the leading cause of heart attacks and stroke, it has less caffeine than coffee; it refreshes the body particularly the central nervous system, skeletal muscles, heart, and liver.

While there are more than 325 varieties of genus Camellia, only two varieties of Camellia Sinesis are commercially viable for producing tea: Camellia sinensis var. Sinensis and Camellia sinensis var. Assamica. There are, however, many cultivars of tea plants available today for producing different styles of tea. Cultivar refers to 'cultivated variety' of tea, reproduced intentionally through vegetative propagation for possessing certain desirable qualities.

Chemical Composition

The chemical composition of green tea varies with genetic strain, climatic conditions, soil properties, plucking season, position of the leaf, processing and storage. Main classes of compounds present in green tea are

Catechins or Flavan-3-ols

Flavan-3-ols, commonly referred to as catechins, comprise about 30% of the total dry weight the leaf. This compound is more abundantly present in non-fermented teas, such as green tea, and are believed to aid cell metabolism to a large extent.

Tannins

Tannis are polyphenolic biomolecules that lend astringency to the tea. The astringency from the tannins dries the mouth and causes puckering. Tannins also play an important role in ripening and aging of a plant.

Theaflavin

Theaflavins are antioxidant polyphenols formed during the enzymatic oxidation of a leaf. During oxidation process (for oolongs and black teas), most of flavan-3-ols or catechins get converted into theaflavins (dimers) and/or therubigins (polymers). Theaflavin is said to be responsible for producing a dark, reddish-brown-colored tea liquor and also for granting astringency to the tea.

Thearubigins

Thearubigins are the most abundant group of [polymeric] polyphenols that are formed during enzymatic oxidation of tea leaves. Being highly water soluble, they account for 30-60% of compounds in an oxidized tea. Thearubigins are red in color, and their concentration is what gives black its range of colors – from amber to dark brown.

Vitamins

Vitamins have various effects on the human body. Regularly drinking green tea, which is full of vitamins, is good for your health.Vitamins, along with saccharides, lipids, proteins and minerals, are one of the five primary nutrients used by the body. Green tea is known for having more vitamins in higher concentrations than other foods, and this fact alone makes tea a superior beverage. It contains Vitamin , Vitamin B2 , Beta-carotene

Saponin

Saponins are found in all teas, and result in the frothing seen in teas like Matcha. Tea leaves contain around 0.1% saponins, which give it its strong bitterness and astringency. Saponins have anti-fungal, anti-inflammatory, and anti-allergy properties and have been shown to lower blood pressure and prevent obesity and influenza (according to studies by the ITO EN Central Research Center).

γ-aminobutyric acid （GABA）

GABA is formed when raw leaves are left without oxygen. GABA contains elements that have been reported in animal testing of Gabalong and Green tea to reduce blood pressure.

Minerals

Minerals play an important role as bodily regulators. Tea contains around 5-7% minerals, mainly potassium (K), calcium (Ca), phosphorus (P), and magnesium (Mg), as well as small quantities of manganese (Mn), zinc (Zn) and copper (Cu).

Caffeine

Around 11 mg of Caffeine is found in 100mg of leaves of green tea. Caffeine acts as an excellent stimulant. However the caffeine content also depends on how the tea is brewed. Caffeine is mainly a tri-methyl derivative of purine 2,6-diol and is produced from leaves of green tea plant.

Carbohydrates

Green tea contains near about 40% total carbohydrate and cellulosic fibre constitute one-third of it.

Lipid

Oil content of green tea leaves is 4% by weight. The tea oil is non drying and its solidifying temperature is -5 to 15 ° C.

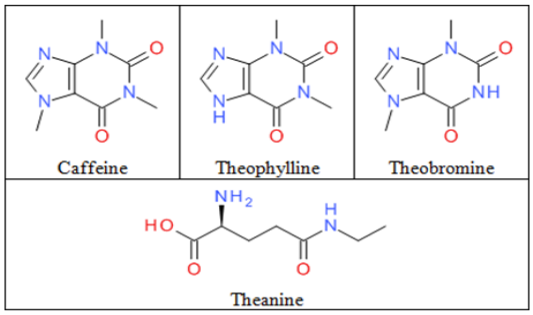

Figure 7: Main constituents for Green Tea

Table1: A comparison drawn between Matcha Tea and Green Tea on basis of its constituents.

Constituents	Matcha Tea (10gms)	Green Tea (10gms)
Polyphenol (Tannins)	1.0g	0.07g
Proteins	3.1g	0.2g
Fibres	3.9g	……
Calcium	42mg	3mg
Iron	1.7mg	0.2mg
Potassium	270mg	27mg
Vitamin A	480 micro g	0
Vitamin B1	0.06mg	0
Vitamin B2	0.14mg	0.05mg
Vitamin C	6mg	6mg
Carotene	2900 micro g	0
Caffeine	0.3 g	0.02g

The Main Chemical Constituent

CATECHIN

Catechin is a flavan-3-ol, a type of natural phenol and antioxidant. It is a plant secondary metabolite. It belongs to the group of flavan-3-ols (or simply flavanols), part of the chemical family of flavonoids. The name of the catechin chemical family derives from catechu, which is the tannic juice or boiled extract of Mimosa catechu (Acacia catechu).The mode of antibacterial action of, the green tea (Camellia sinensis) extracts, (-)-epigallocatechin gallate (EGCg) and (-)-epicatechin (EC) was investigated.[24]

There are four main types of catechins found in tea leaves:
Epicatechin. Epigallocatechin, Epicatechin gallate, Epigallocatechin gallate.

In addition, during the manufacturing process for tea beverages, owing to heat processing, some catechins change their form.

Epicatechin → Catechin

Epigallocatechin → Gallocatechin

Epicatechin gallate → Catechin gallate

Epigallocatechin gallate → Gallocatechin gallate

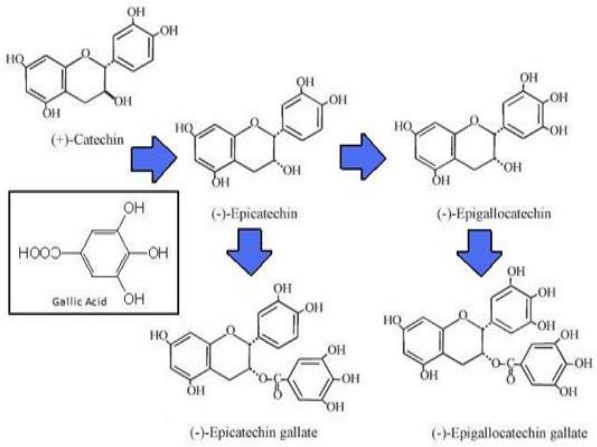

Figure 8: Different forms of Catechin

From various studies and research works, EGCg has been shown to induce apoptotic cell death and cell cycle arrest in tumour cells but not in their normal counterparts; it also favourably affects several signal transduction pathways and is efficacious in animal models of tumour induction. On the strength of such studies, EGCg has successfully undergone Phase I (human safety) trials, and patients with asymptomatic Rai stage 0–II chronic lymphocytic leukaemia are currently being recruited to participate in a Phase I/II trial of EGCg to be conducted by the US National Cancer Institute. These activities are creating a precedent for therapeutic interventions with natural polyphenols or their synthetic structural analogues.

Catechin-containing extracts were thought to be useful for treating heart diseases, and an effect on the permeability of capillaries was shown in 1936.Limited evidence from dietary studies indicates that catechins may have an effect on endothelium-dependent vasodilation which could contribute to normal blood flow regulation in humans. Green tea catechins may improve blood pressure, especially when systolic blood pressure is above 130 mmHg. Catechins and their metabolites can bind to red blood cells and possibly induce release of autoantibodies, resulting in haemolytic anaemia and renal failure. This resulted in the withdrawal of the catechin-containing drug Catergen, used to treat viral hepatitis.[15]

Oral Infections, Tooth Decay and Mouth Ulcers

Compounds present in both green and black teas have been shown to inhibit the growth and activity of bacteria with tooth decay producing halitosis. It is found that humans that have tea compounds in their drinking water develop fewer dental caries andless plaque formation than those drinking plain water. Tooth decay is the gradualbreakdown of the tooth beginning with theenamel surface and eventually progressing tothe inner pulp. Tooth decay and, eventually, halitosis are caused by acids produced bycertain mouth bacteria in dental plaque.

Teeth with significant decay are saidto have caries or cavities. Plaque is another contributor to bad breath.

The phenolic compound in green tea block the growth of bacteria responsible for teeth cavity and plaque formation.1, [27]

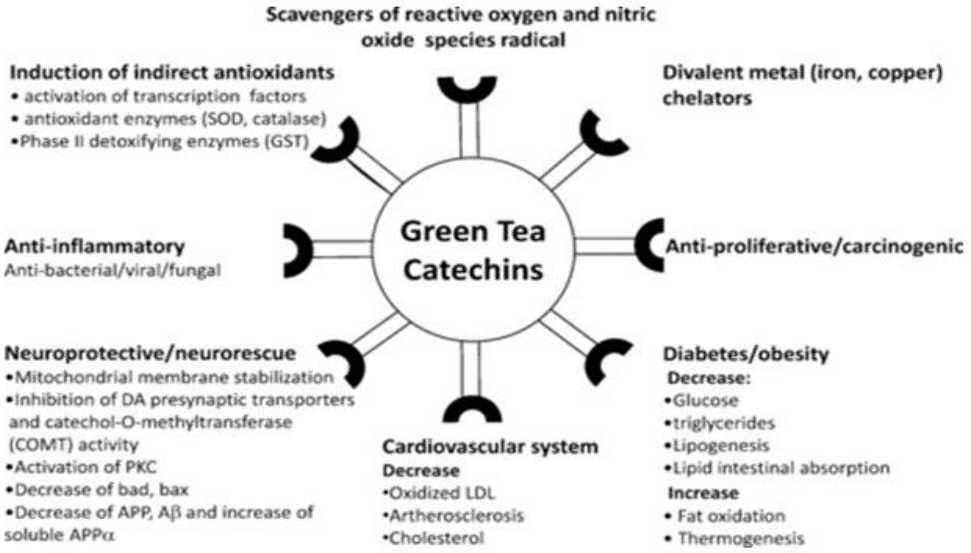

Figure 9: Antimicrobial Properties of Green Tea

Sore Throat

Green tea is a natural, anti-microbial, and harmless substance that can reduce the prevalence of sore throat. Drinking green tea prevents getting sore throats and colds since it helps fight the bacteria harboring in the throat and various researches have been carried out that explore the effect of green tea gargling on sore throat caused by intubation in patients after CABG surgery. The results showed that green tea gargling was effective against sore throat 12 and 24 hours after removal of endotracheal tubes.[25]

Stomach and Intestinal Infections

Helicobacter pylori is one of the most common chronic bacterial infections in man. Following the discovery of the linkage between gastric adenocarcinoma and *H. pylori* infection, antibiotic therapy became an important tool in *Helicobacter* eradication. Various chemical components of green tea have been suggested to have anti-*H. pylori* effects in vitro, in vivo correlation is sparse. Interestingly, the combination of the main component of green tea (catechins) and sucralfate has a bactericidal effect on *H. pylori* infection in Mongolian gerbils and green tea catechins may inhibit the *H. pylori* urease.

Skin Infection Acne Vulgaris

Several researches show that green tea extract play a vital role in curing various skin infections caused by microbes which might be fungal or bacterial infections namely Acne Vulgaris, pimples and other breakouts in skin. It has been found that it can help to repair the damage from the sun, prevent premature aging and enhances skin tone too. It's the combination of its antioxidant and antimicrobial properties that make it an attractive ingredient helpful for skin rejuvenation.[2]

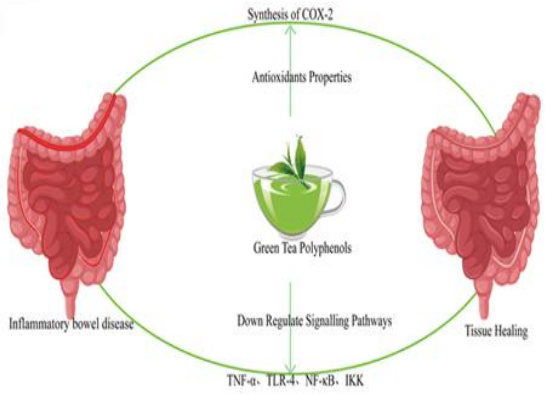

Figure 10: Action of Green tea in Inflammatory Bowel Disease

Urinary Infections

Escherichia coli is the most common cause of urinary tract infections. The development of antibiotic resistance in *E. coli* is an important problem. Finding alternative antimicrobial agents from plant extracts has received growing interest. *Camellia sinensis* is a safe, nontoxic, cheap beverage that has been reported to have antimicrobial effects against various pathogenic bacteria including *E. coli.* Polyphenolic components of green tea have antibacterial activity. Catechins also have synergistic effect with antibiotics such as chloramphenicol, amoxicillin, sulfamethoxazole, azithromycin, levofloxacin, gentamycin, methicillin, and, especially ciprofloxacin. Various data on *In vivo* studies have shown considerable importance on antibacterial effects of green tea and evaluating the efficacy of its catechins in the treatment of urinary tract infection (UTI).[8]

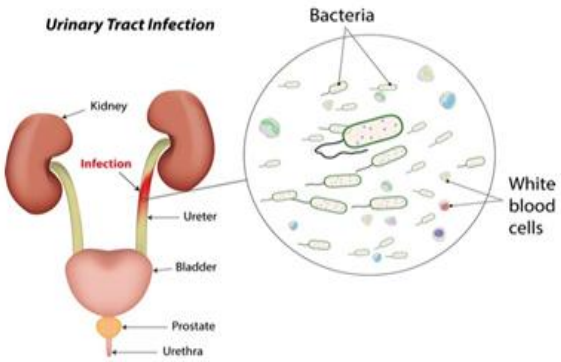

Figure 11: UTI caused by E. Coli

MECHANISM OF ANTIMICROBIAL ACTIVITY

A number of epidemiological surveys have indicated that green tea consumption is linked to lower incidences of various pathological conditions, including cardiovascular disease, strokes, obesity and cancer. Recent clinical studies have revealed physiological responses to tea extracts that may be relevant to the promotion of health, as well as the prevention or treatment of these chronic diseases; furthermore, inconsistencies between some studies should be soon be resolved by improved approaches to their evaluation. These effects have been attributed, in part, to the antimicrobial, antioxidative and free radical scavenging activities of the polyphenolic components. Evidence has recently emerged, however, to suggest that these molecules have the capacity to modulate the physical structure of cell membranes. Thus, a number of membrane-dependent cellular processes, such as cell signalling and the cell cycle, arachidonic acid metabolism and cell proliferation, and apoptosis and mitochondrial functionality may be influenced by the interaction of catechins with the cellular phospholipid palisade.[7]

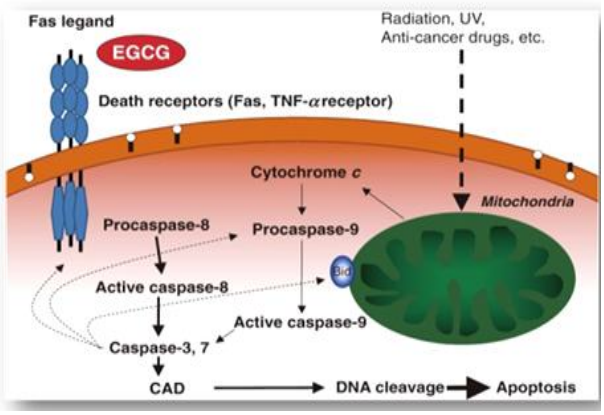

Figure 12: Mechanism of Antimicrobial Activity

Strong bactericidal EGCg caused leakage of 5,6-carboxyfluorescein from phosphatidylcholine liposomes (PC), but EC with very weak bactericidal activity caused little damage to the membrane. Phosphatidylserine and dicetyl phosphate partially protected the membrane from EGCg-mediated damage when reconstituted into the liposome membrane with PC. EGCg, but not EC, caused strong aggregation and NPN-fluorescence quenching of PC-liposomes and these actions were markedly lowered in the presence of negatively charged lipids. These results show that bactericidal catechins primarily act on and damage bacterial membranes. The observation that Gram-negative bacteria are more resistant to bactericidal catechins than Gram-positive bacteria can be explained to some extent by the presence of negatively charged lipopolysaccharide.[22]

Other Therapeutic Effects of Green Tea

Other than exhibiting Antimicrobial properties green tea is known to possess anti-inflammatory, anti-bacterial, anti-fungal and anti-oxidative property. All these properties together helps in boosting overall immunity and thus help in prevention of many diseases and/or ailments which are as follows:

DIABETES

Various studies have shown the beneficial effects of green tea, not only on cardiovascular diseases but also on obesity and type 2 diabetes itself. According to a comprehensive review, green tea consumption is associated with decreased fasting glucose levels and A1C levels, as well as reduced fasting insulin levels, which are a measurement of diabetes health. [In a retrospective cohort study performed in Japan, a 33% risk reduction of developing type 2 diabetes was found in subjects consuming six or more cups of green tea daily compared to those consuming less than 1 cup per week]. However, a limited number of clinical trials using green tea, green tea extracts (GTEs), or its main ingredient catechin have shown disappointing results in controlling hyperglycemia in type 2 diabetic patients or protecting the condition in healthy subjects.

[Indeed, one animal study found that EGCG was as effective as the diabetic drug Avandia in moderately diabetic mice, suggesting green tea, or a high-quality green tea extract, could be helpful for the prevention and/or treatment of diabetes.]

OBESITY

Evidences from epidemiological studies suggest the possibility of green tea being a novel strategy for treatment or prevention of obesity and diabetes. It has been shown that green tea helps to reduce obesity when consumed on daily basis. Anti–obesity effect of green tea has been associated with its content of caffeine and catechins particularly (−)–epigallocatechin–3–gallate (EGCG). Many human epidemiological studies, demonstrated beneficial effects of green tea or green tea catechins rich in EGCG in overweight management. The consumption of green tea or its catechins helps in significant reduction of body mass index (BMI), body weight and body fat by increasing postprandial thermo genesis and fat oxidation and thus also reducing cholesterol.

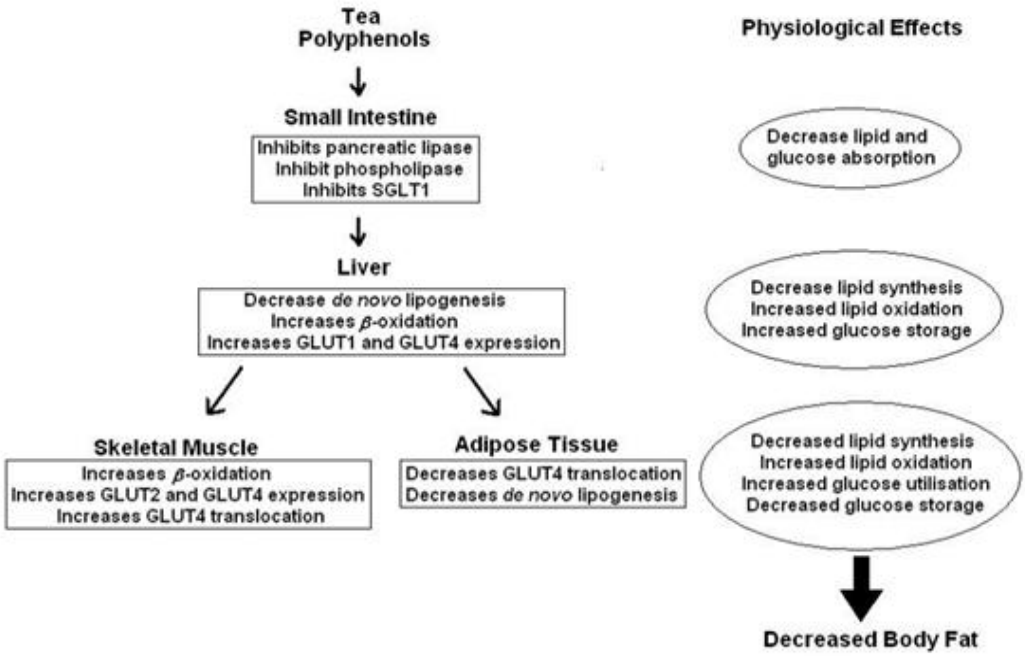

Figure 13: Mechanism of Tea Polyphenols in reducing body fat

CANCER

Green Tea Polyphenols (GTP), particularly EGCG or EGCg (epigallocatechin gallate) not only inhibit an enzyme required for cancer cell growth, but also kills cancer cells with no ill effect on healthy cells. A team of scientists at Purdue University determined: "In the presence of EGCg, the cancer cells literally failed to grow or enlarge after division then presumably because they did not reach the minimum size needed to divide they underwent programmed cell death, or apoptosis." Although not all studies gave positive result about green tea inhibiting or preventing growth of cancer cells.[41]

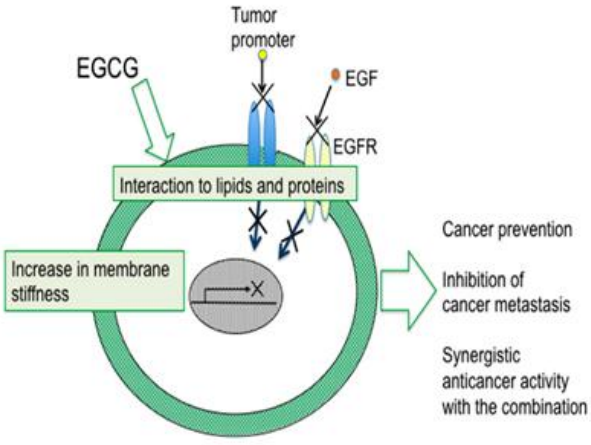

Figure 14: Mechanism induced by EGCG in Cancer

Hypertension

Some of the latest research confirms that regular intake of green tea prevents high blood pressure. [The systematic review, published in the *British Journal of Nutrition* in October concluded that long-term tea intake significantly improved blood pressure. As reported in *Time Magazine*]

Preventing Alzheimer's Disease and Enhancing Function of Brain

Researchers have also discovered that green tea has the potential to enhance the function of brain, and preventage-associated brain degeneration. Specifically, EGCG appears to decrease the production of the protein beta-amyloid, which can over-accumulate in your brain, resulting in nerve damage and memory loss over time12 – a condition related to Alzheimer's disease.

[In one study, 13 published in 2005, researchers injected pure EGCG into mice genetically programmed to develop Alzheimer's; the results showed a decrease of as much as 54 percent in the plaque associated with Alzheimer's.]

GLAUCOMA

Catechins in green tea may also help protect against glaucoma and other eye diseases. In an USA based study, 14 scientists analysed eye tissue from rats that drank green tea and found that eye tissues such as the lens and retina had in fact absorbed green tea catechins which had improved their eyesight by 20%.

ARTHRITIS

Green tea is rich I polyphenols which seems to have anti-inflammatory properties in animal testing lab. One laboratory experiment suggested that it has positive effect on collagen-induced arthritis in mice.

Another extra benefit was that the total IgG and Type 2 collagen specific IgG levels were found lower I the serum and arthritic joints of the mice treated with polyphenols.

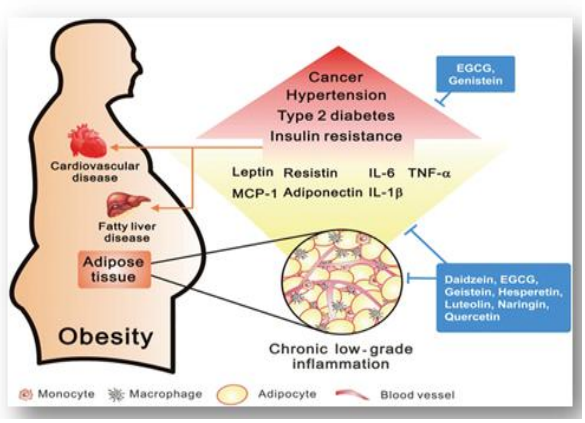

Figure 15: EGCG in preventing inflammation in body.

DISCUSSION

Human population growth, technological advances, and changing social behaviours lead to the selection of new microbial pathogens. Emerging infectious diseases are caused by new or previously unrecognized microorganisms.

By going through and reviewing various articles, we found that green tea can be used as an excellent antimicrobial agent. Green tea extracts are infused in various dosage forms such as creams, gels, ointments, lotions and taken in the form of decoction itself.

CONCLUSION

Through this entire study carried on Anti-microbial properties, it may be concluded that Thea-sinensis (green tea) is potent enough to prevent or cure most of the microbial infections. Naturally occurring catechins have a wide range of activities on bacteria, not all of which include the capacity to exert bactericidal or bacteriostatic effects, and some of these are showing early promise with regard to modulation of the host – pathogen relationship. However, unless substantial chemical modifications to the catechin structure can be made that result in significant improvement in both antibacterial efficacy and stability *in vivo*, these molecules are unlikely to be useful as conventional anti-infective agents for the treatment of severe systemic infections.

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