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Epigallocatechin Gallate–Pharmacological Benefits and Bioavailability: A Review

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ABSTRACT

The compound Epigallocatechin gallate (EGCG) a catechin is a major polyphenol found in green tea. This polyphenolic compound is linked with several health benefits. The potential health benefits include antioxidant effects, cancer chemoprevention, improving cardiovascular health, aiding in weight loss, and protecting from skin damage caused by ionizing radiation, and others. It is prone to decreased stability, lower bioavailability, and lower absorption rate due o various environmental, processing, formulation, and gastrointestinal circumstances of the human body, and is being extensively researched for improvement in functional meals. Enhanced thermogenesis (heat production), enhanced fat oxidation, greater muscular glucose absorption, decreased hepatic fat content, and increased faecal fat excretion are further advantages. The purpose of this review is to highlight the pharmacological benefits of Epigallocatechin-3-gallate and to express the potential of EGCG and the necessity of further research on this therapeutic compound to expand its use in various food industries.

Keywords: Phytoconstituents; Reactive oxygen species; Soy protein hydrolysates; catechin; Nanoparticle

1. INTRODUCTION

Across the globe, herbal medicines are frequently used as medicinal agent for the management and treatment of a huge range of illnesses. Despite the enormous advances in the present medical system, medicinal plants continue to be crucial to human health. Numerous native plants have been used to treat a huge range of illnesses from the beginning of time. One of the oldest and most thoroughly studied medicinal plants is Camellia sinensis, which has been extensively used as a natural remedy since ancient times. Tea is a beverage produced by the plant of tea leaves and buds of family Camellia sinensis.

Green tea contains a number of nutrients and useful ingredients, such as polyphenols and flavonoids-3-alcohols; also referred to as catechins which constitute a total of 30-42% dry weight of tea leaves.

Green tea's composition is dominated by flavanols, with catechins accounting for almost one-third of the leaf's dry weight. Catechins consist of four molecules: epicatechin (EC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG)[1]. EGCG is the most common and therapeutically effective catechin present in green tea, which accounts for total 65 % of catechin content[2]. EGCG is a chemical compound which is composed of a flavanol core structure (flavan-3-ols), a gallocatechol group, and a ester-gallate. These two gallocatechol rings provide EGCG with significant antioxidant and chelating effects[3,4]. (Fig. 1) depicts the molecular structures of these compounds.

EGCG is a strong antioxidant and is also an anti-inflammatory, antibacterial, and antiviral agent which is capable of modulating different pathways that target the body, including Nuclear Factor-kappa B (NF-B), Epidermal Growth Factor Receptor (EGFR), the Phosphatidylinositol 3-Kinase (PI3K)/Akt Pathway and Mitogen-Activated Protein Kinases (MAPKs), Matrix Metalloproteinases (MMPs) and also used in altering the lipid metabolism.

Nanotechnology is a technique that could be used to significantly enhance the bioavailability of this catechin, nanocarriers have the potential to alter the pharmacokinetics and stability of EGCG [5]. There are different types of EGCG delivery nano systems such as lipid-based, Liposomes, nanoparticles which are polymeric, nanoparticles with gold, inorganic nanocarriers, and protein/peptide-based nanocarriers. The most often employed EGCG delivery nanocarriers are polymeric and lipid-based nanocarriers.

2. PHARMACOLOGICAL ASPECTS OF EGCG

EGCG which is derived from green tea has long been regarded as a medicinal herb and a healthful beverage. This plant is used in Chinese medicine for treating pains, aches, digestion, energising, headaches, detoxification, depression, and generally extending life [6]. As a result of its numerous advantages including cancer and weight reduction, green tea has recently gained a lot of attention from both the scientific and consumer populations. Green tea's ingredient catechins, which are well recognised for their antioxidant capabilities, and

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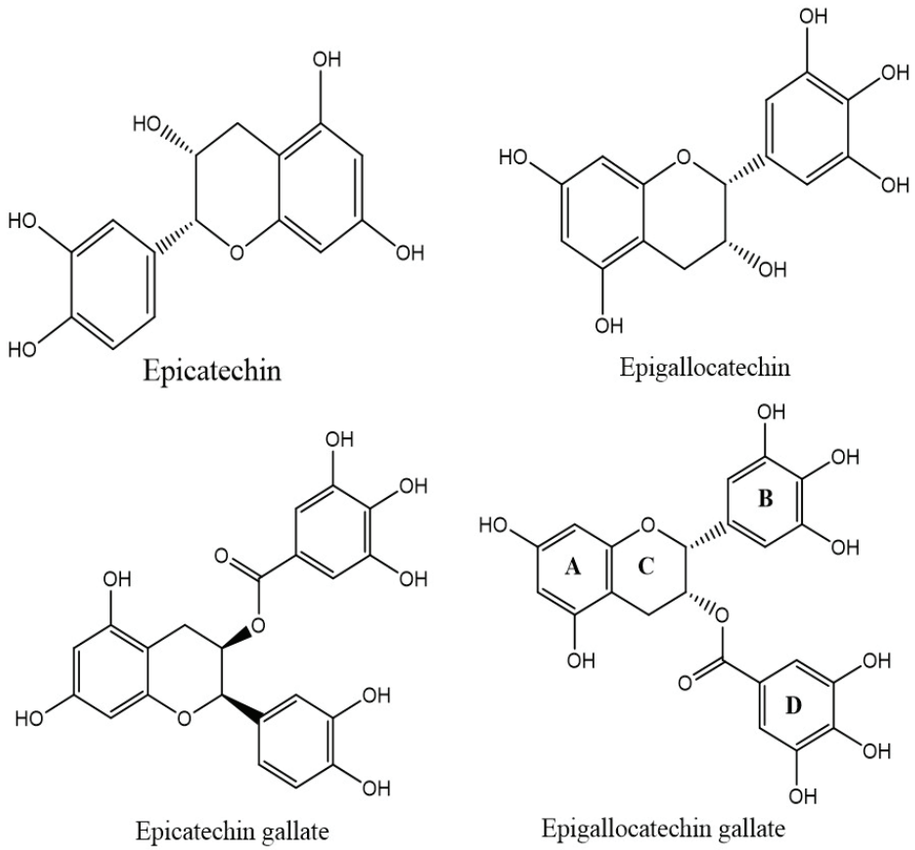

Figure 1. Molecular structure of catechins

have been studied in relation to a variety of disorders like cancer, cardiovascular, and neurological diseases that are caused by reactive oxygen species (ROS)[7].

2.1 Anti-cancer

The regulation of different cancers is significantly influenced by EGCG. The main goal of research on anticancer compounds is to introduce apoptosis into cancer cells and inhibit carcinogenesis. The unique function of EGCG in preventing different malignancies is discussed below, based on *in vitro* research. Debolina Pal and other reportedly looked at the antitumor effects of EGCG and amarogentin both separately and together. It was discovered that the combination of EGCG and eugenol-amrogentin had a greater ability to control colony formation and cellular proliferation than either compound alone. Moreover, EGCG combined with eugenol-amrogentin therapy led to higher levels of apoptotic induction than either component alone[8].

Analysing alterations in the gene expression patterns of recognised angiogenesis-related genes will help determine whether EGCG treatment has an anti-angiogenic effect on tumour cells. The results show that EGCG administration significantly increases the number of genes known to have antagonistic effects while significantly downregulating genes involved in increasing proliferation, invasion, adhesion, and motility activities[9]. As a result, EGCG would be a critical method for inhibiting the multiplication of breast cancer cells in culture. Breast cancer cell growth was inhibited by EGCG.

To find out how EGCG affects glucose metabolism, studies were done. In addition, EGCG reduced the expression of glucose transporter-1 and hypoxia-inducible factor 1α, which are important regulators of glycolysis[10]. Additionally, 80 μM of EGCG significantly enhanced PTEN gene expression and lowered Akt to a level comparable to tamoxifen. The same amount of EGCG significantly raised the Bcl-2/Bax ratio in terms of gene expression. It dramatically enhanced protein expression of Bax/Bcl-2 by six times, while the tamoxifen group had a ten-fold increase in this ratio. They conclude that EGCG may be a useful adjuvant therapeutic agent for the treatment of breast cancer[11].

Moreover, it stops pancreatic cancer cells from migrating and invading healthy tissue. The causative mechanisms underlying EGCG's prominent impact in preventing pancreatic cancer cell invasion and migration were examined. This substance reduced the invasion, proliferation, and migration of pancreatic cancer cells. To reduce the migration, invasion, and proliferation of pancreatic cancer cells, gemcitabine and growth were also combined[12]. EGCG and bleomycin boosted the anti-proliferative effects *in vitro* by causing the death of pancreatic cancer cells. A new approach to treating

pancreatic cancer may be possible with the help of such combination[13]. EGCG has antiproliferative and antimigratory actions on bladder cancer and has therapeutic effects on the urinary bladder.

According to reports, treatment with this green tea ingredient significantly reduced cell growth by inducing apoptosis, without significantly toxicating healthy bladder epithelial cells. Moreover, it also prevented cancer cells from migrating and invading other tissues, and it caused cancer cells to die[14]. Because EGCG caused anti-cancerous epigenetic changes, it has been demonstrated that it can reduce acute leukaemia cell apoptosis and proliferation[15]. Investigated were the catechin's effects on the acute promyelocytic leukaemia cell line's cell cycle and proliferation. The outcome revealed that EGCG treatment of leukaemia cells suppressed proliferation and cell cycle progression and displayed time- and dose-dependent properties[15]. In addition to chemotherapy drugs including cisplatin and etoposide, radiation was also given. After the occurrence of grade II esophagitis, oesophageal toxicity, dose escalation, and discomfort reported by the patient were also monitored on a weekly basis. Six patient groups received EGCG therapies at six different dose levels. There were no dose-limiting toxicities seen it across all dosing levels. After the radiotherapy was finished, only 2 of the 24 patients with grade 2 esophagitis remained affected, whereas 22 of the 24 patients had a severe regression of their esophagitis to grade 0/I. The conclusion drawn from this finding is that oral delivery of EGCG is practical, secure, and efficient[16].

2.2 Antiviral Activity

EGCG may lessen the impact of HIV infection on host cells. The major receptor CD4 on the surface of host cells is initially bound by the outer membrane glycoprotein 120 (gp120) of HIV-1 when it infects the cells The prostatic acid phosphatase (PAP248-286 and PAP85-120) and semenogelins (SEM1 and SEM2) proteolytic fragments in semen generate amyloid fibrils that act as semen-derived enhancers of virus infection (SEVI). SEVI have the capacity to greatly increase HIV infectivity. According to Castellano et al. (2015) and Duan et al. (2012), EGCG can modify SEVI and PAP248-286 and stop the development of amyloid fibres. Furthermore, it has been shown that EGCG inhibits HIV reverse transcription, which stops the replication of strains of HIV. EGCG a naturally occurring anti-HIV drug is a promising contender as a replacement in HIV-1 therapy because its inhibition can be attained in physiologic proportions. Because it is a naturally occurring anti-HIV drug[17].

According to research, EGCG greatly reduces HIV transcription and recognition, raising the possibility that it could be used as an AIDS treatment. In infected host cells, transcription is a critical step in the creation of the HIV-1 gene. The HIV-1Tat initiates kappa B (NF-kappa B)- nuclear factor and signals transduction pathway, that lowers intracellular glutathione expression and increases ROS generation. Tests on the effects of EGCG on MAGI cell lines that had been activated by the HIV-1 Tat protein showed that it enhanced Nrf2 and AMPK expression while decreasing NF-kB activation and ROS accumulation. It is thought that EGCG's primary target for inhibiting Tat-induced HIV-1 transactivation. EGCG also reduced NF-kappa B activity via increasing AMPK signalling and decreasing AKT signalling. These all result in the inhibition of HIV-1 gene transcription[18].

Epicatechin is a green tea and cocoa leaf monomeric flavonoid that easily passes the blood-brain barrier. Because of this, the neuroprotective properties of catechin, epicatechin, and EGCG against the HIV proteins Tat and gp120 were further examined and contrasted with resveratrol. By focusing on the brain-derived neurotrophic factor (BDNF) and its precursor pro BDNF signalling pathways, epicatechin and EGCG normalise concurrent Tat-mediated declines in the mature BDNF protein and proapoptotic pro BDNF elevations in hippocampus neurons. More effective neuroprotectants than catechin or resveratrol were epicatechin and epigallocatechin gallate. For neurodegenerative conditions, such as HIV-related neurocognitive impairments, epicatechin may be the best therapeutic candidate[19]. Jiang and colleagues used the ELISA technique to assess the activity of the catechins gallate , epicatechin gallate, epigallocatechin gallate, and gallocatechin gallate. By binding to Tyr143, they discovered that the catechins gallate (CG), epicatechin gallate (ECG), epigallocatechin gallate (EGCG), and gallocatechin gallate (GCG) significantly block HIV-1 integrase[20].

2.3 Neuroprotective Effects

Phytomedicines, such as green tea, are used to treat neurodegenerative illnesses. Studies have given the value of green tea for treating neurodegenerative disorders. The following Table 1 mostly illustrates the neuroprotective impact.

Table 1. EGCG showing Neuroprotective effects

Disease affects Neuro	Inference
1) Alzheimer's disease	• Black tea demonstrated less beneficial benefits than green tea on hippocampus oxidation and memory loss in AD rats [21]. • L-theanine might be a potential medication to treat AD [22]
2) Parkinson's disease	• Green tea polyphenols (GTP) were able to considerably ameliorate neuronal mitochondrial dysfunction and redox imbalance via circadian rhythm regulation [23].
3) Cerebral ischemia	• Due to the suppression of MMP-9 activity, following cerebral ischemia, EGCG (50 mg/kg) may decrease neuron damage [24]. • By lowering the formation of lipid peroxides and oxidised DNA damage, Polyphenols of green tea (400 mg/kg) could enhance spatial cognition [25].

4) Brain injury	• Inhibiting the death of dopaminergic cells brought on by DDT was EGCG [26]. • Moreover, the Extraction of green tea 5 µg/L effectively defended rats' brains from DNA damage and oxidative stress [27]. • To counteract the cognitive impairment brought on by isoflurane, use of polyphenols from green tea (GTP) in dose of 25 mg/kg for a period of 7 days is beneficial. [28].

2.4 Antioxidant

The main characteristic of EGCG that makes it so desirable to be added to foods and beverages is its antioxidative action. Antioxidants are substances that defend cells from reactive oxygen species (ROS), including singlet oxygen, peroxyl, superoxide, peroxynitrite, and hydroxyl radicals. Popular nutraceutical ingredient that functions as an antioxidant is green tea. EGCG's antioxidant activity can be increased by chelating free transition metals, inhibiting cell signalling pathways such as NF-kB, AP-1, COX-2, ICAM-1, STAT, and MAPK, activating antioxidants such as SOD, CAT, GSH, GPx, and GST, inhibiting iNOS, scavenging ROS, and inhibiting pro-oxidants that produce superoxide (xanthine oxidase, NADPH oxidase, COX-2 lipoxygenase)[29].

Antioxidants are thought to function as HAT (hydrogen atom transfer) and (SET) single electron transfer. The ability of the plasma to reduce ferric serves as a good SET-based analysis method (FRAP). In this process, the tripyridyltriazine (TPTZ) and Fe+3 complexation oxidises the antioxidant. The antioxidant thus donates one electron to the Fe+3-TPTZ complex. The ability of the antioxidants to diminish, which gives electrons, is reflected in the subsequent shift in absorbance. The oxygen radical absorbance capacity (ORAC), a common HAT technique, depends on the production of peroxyl radicals (ROO) by a radical initiator. The antioxidant neutralises the ROO and stops it from interacting with the fluorescent probe by adding a hydrogen atom to it. Thus, the rate of fluorescence decay is slowed down by higher antioxidative activity[30].

The octanol-water partition coefficient indicated that the EGCG ester derivatives with stearic acid (SA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) have better lipophilicity. The 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical can be neutralised by the 1,1-diphenyl-2-picrylhydrazyl (lipophilized EGCG derivatives) antioxidant activity, which is stronger than that of the original EGCG. The findings point to the possibility of using EGCG derivatives as lipophilic antioxidants in the food, cosmetics, and pharmaceutical sectors[31].

Soy protein hydrolysates (SPHs) showed a synergistic impact in enhancing the antioxidant capacity when EGCG was supplied along with them. The author's theory was supported by the data, which suggested that EGCG conjugation with SPHs enabled protein flexibility to unroll and stretch. The use of SPHs-EGCG conjugates as an efficient emulsifier to produce emulsion systems should aid the development of functional beverages which contain polyphenols and peptides thus having higher nutritional qualities[32].

A different study found that the signalling of numerous non-alcoholic fatty liver disorders (NAFLDs) was accelerated by oxidative stress, which is mostly brought on by an excessive buildup of ROS. For the treatment of NAFLD, maintaining redox homeostasis and reducing oxidative stress may be effective strategies One of the most important dietary sources of natural antioxidants is green tea, and it particularly benefits from the antioxidative properties of EGCG, which is a type of catechin. EGCG and Green tea show positive effects on NAFLD prevention, the associated metabolic dysfunction, and management by reducing oxidative stress and inflammation, fibrosis, and tumorigenesis with acceptable patient safety. This information has been gathered through randomised clinical trials, systematic reviews, and meta-analyses. Targeted signalling pathways includes and also not limited to, AMPK, NRF2, NF-κB, PI3K/Akt/FoxO1, TGF-β/SMAD, TLR4/MYD88, and SIRT1, etc[33].

Moreover, EGCG is enzymatically changed to improve its lipophilicity and antioxidant properties. When compared to EGCG, EGCG lauroyl derivatives demonstrated good lipid oxidation. Significantly EGCG lower at 21 days than those of EGCG by 42%, 47%, and 57%, respectively. This indicates that by substituents addition decreases the antioxidative inhibition of these derivatives. This shows that the application of these compounds as antioxidants has a wide scope[34]

2.5 Anti-diabetic

Tea catechins, particularly EGCG, seem to have actions that are both anti-obesity and anti-diabetic. Green tea's biological significant effect is anti-diabetic properties. According to recent research, there are mainly four mechanisms for green tea's effects of anti-diabetic illustrated in Table 2.

Table 2. EGCG anti-diabetic mechanism

Mechanism	Inference
Mechanism-1 Improving insulin resistance	• 80 mg/kg extract from green tea for a period of 12 weeks can enhance sensitivity to insulin and distribution of lipids via modifying the expression of genes involved in homeostasis of glucose and lipid, such as GLUT-4, LPL, and PPAR. Ultimately, this reduces the blood glucose levels and insulin resistance in overweight dogs [35].
Mechanism-2 Improving glucose metabolism	• Revealed that diabetic rats induced with streptozotocin responded significantly to green tea extract for 30 days (75 mg/kg). Additionally, it had blood sugar-lowering abilities comparable to those of taking metformin orally. M.O.A. was attributed to changed glucose metabolism-related enzyme activity and increased glycogen accumulation in the liver [36].

Mechanism-3 Promoting insulin secretion	• Polysaccharide isolated (7WA) that is water soluble derived from green tea leaves. With a potential mechanism involving cAMP-PKA dependent pathways, 7WA could enhance insulin production and have a sizable hypoglycemic effect [37]
Mechanism-4 Improving diabetic complications	• In diabetic pregnant mice, the rate of neural tube abnormalities was significantly reduced by 10 M EGCG therapy, going from 29.5% to 2%. The ability of 10 μM EGCG to stop DNA hypermethylation in maternal diabetic mice by inhibiting the enhanced activity and expression of DNA methyltransferase may be responsible for this effect [38].

2.6 Obesity

The health of many populations is at risk due to the rapidly expanding, medically acknowledged issue of obesity and overweight in affluent nations. It is characterised by an excessive fat, which negatively affects both mental health, physical, and well-being. Examples of these conditions include osteoarthritis, non-insulin-dependent diabetes, pulmonary dysfunction, and coronary heart disease. There has been an increase in interest in tea's impact on diabetes and obesity. Tea catechins, particularly EGCG, seem to have anti-obesity properties. After a 12-week dietary intervention, Liu and colleagues found that oxidised tea phenolics (OTP) and green tea phenolics (GTP) had equal anti-obesity effects[39]. The anti-obesity qualities of green tea extract (GTE) are examined by Zang and colleagues in a distinct investigation using zebrafish larva. GTE significantly decreased plasma triglyceride, total cholesterol levels, and also visceral fat caused by a high-fat diet. According to the research, drinking green tea regularly may help prevent and treat obesity[40]. Quercetin and Epigallocatechin gallate (EGCG) showing in research to have anti-obesity effects in adipocyte cultures and animal models. It is unclear, though, how these possible advantages might apply to fat people. Despite the fact that supplementation like quercetin does not seem to have any valuable effects on human body weight, it may lessen the risk of cardiovascular disease, hence lowering the mortality rate associated with obesity. The anti-obesity effects may be helpful by dropping the cardiovascular risk of obese individuals instead of producing weight loss in the body, even if the evidence is more consistent with EGCG study than with quercetin studies[41]. The effect of anti-obesity of green tea extract is enhanced by diallyl disulfide (DADS), according to research by Bae and colleagues. This improvement is followed by the activation of the PPAR axis and the inhibition of the sterol regulatory element-binding protein-1 (SREBP-1) pathway. A unique and practical strategy for preventing diseases linked to obesity is the combination diet[42].

3. IMPROVING ORAL BIOAVAILABILITY OF EGCG BY FOOD BY NANO-DELIVERY

Nanoparticles can protect bioactive molecules or components from the effects of the gastrointestinal environment by embedding them into their interiors or surfaces of adsorption materials, which enables steady, sustained release and increases biological activity. Catechins, which are found in many fruits and vegetables, provide a number of health advantages but are susceptible to oxidation. Several pieces of research indicate that using properly engineered nanoparticles to deliver catechins may have better health effects[43]. Nowadays, EGCG has undergone considerable research involving the embedding and transport of nanoparticles, nanoemulsions, nanoliposomes, and other wall materials.

3.1 Nanoparticles

The increased specific surface area of the nanoparticle carrier made it easier to improve the particular surface features of the nanoparticles, extend the time that nanoparticles are retained in the small intestine by a significant amount and expand the region where nutrients and adsorbed biofilm come into touch[44]. In a xenograft mouse model of GC, si-TMEM44-AS1 can be delivered to help reverse 5-FU resistance by silencing TMEM44-AS1 expression. This results in a considerably improved 5-FU therapeutic impact. It was discovered that the chitosan-gelatin-EGCG (CGE) nanocarrier had a better gene silencing efficacy than lipo 2000[45]. Nanoparticles may dramatically increase nutrient absorption and bioavailability and have a protective effect on nutrients. EGCG's stability has been improved by covering it with nanoparticles created by thermally altering -lactoglobulin during the simulation of gastrointestinal digestion. Our research team developed zein-coated embedded EGCG chitosan nanoparticles. Enhancements to DPPH clearance activity and release control were made possible by the composite nanoparticles. The double-layer film coating enhanced the stability of chitosan and EGCG molecules, and ferritin appeared to be protected by the EGCG ferritin-chitosan double-layer nanoparticles. Ferritin was significantly protected by nanoparticles in transport investigations done on Caco-2 cells. Bilayer coating, in particular, improved EGCG consumption[46]. Chitosan-casein phosphopeptide nanoparticles for EGCG were made by Hu and coworkers. The results of the Caco-2 intracellular green fluorescence assay showed that the EGCG-loaded nanoparticles were internalised into the cells. The amount and timing of EGCG absorption varied with incubation time and concentration[47]. Additionally, surface-charged chitosan and polyglutamic acid nanoparticles have the potential to enhance catechin absorption by enhancing the extracellular transfer of EGCG and breaking the strong bond between Caco-2 cells[48]. The gastrointestinal absorption of EGCG is greatly improved by chitosan/trimeric phosphate nanoparticles, increasing EGCG's bioavailability[49]. Following oral delivery, there was a 1.5-

and 2.3-fold increase in the amount of EGCG exposed to the plasma and jejunum, respectively[50].

3.2 Nanoemulsion

To increase EGCG's stability and lessen its adverse effects, a nano-EGCG emulsion was created. An oil phase, a water phase, a surfactant, and a cosurfactant make up a transparent or translucent dispersion known as a nanemulsion. The typical particle size range was between 5 and 200 nm[51]. It may increase the bioavailability, stability, and solubility of insoluble nutrients when used as a carrier. It also has prolonged release and targeting effects due to its unique particle size distribution and structure[52].

Chen and colleagues observed that nano-EGCG inhibited the growth of H1299 lung cancer cells at half-maximal inhibitory dosages of 36.03 and 4.71 μM, respectively. Moreover, this nano-EGCG efficiently and dose-dependently hindered the development, migration, and invasion of lung cancer cells. Matrix metalloproteinase (MMP)-2 and MMP-9-independent methods may be used by nano-EGCG to prevent lung cancer cell invasion. Moreover, nano-EGCG affected the expression of numerous important AMPK signalling pathway regulatory proteins[53].

The addition of epigallocatechin gallate (EGCG) to the nanoemulsion increased the antioxidant activity of the surimi digest. Surimi digest from the gel combined with G-V-N inhibited the growth of five cancer cell lines, including HEK (Human embryonic kidney 293 cells), U87 (Human glioma), HeLa (Human cervical cancer), MCF-7 (Human breast cancer cell line), and IMR-32 (Human neuroblastoma)[54]. The protective activity of 1-Dodecanol and soybean lecithin on EGCG in simulated gastric juice conditions could explain the delayed release of EGCG loaded with nanoemulsion. When tea polyphenols were loaded with nanoemulsion instead of tea polyphenol solution, the absorption of EGCG was dramatically improved by 28.6%. The results showed that tea polyphenols might be progressively released when administered *via* a nanoemulsion approach to boost EGCG absorption[55]. When compared to catechin that had not been nano-emulsified, catechin nano-emulsification significantly increased the Caco-2 cells' apparent permeability coefficient (Papp), and the control group's bioaccessibility was 2.78 times lower than that of the nano emulsified catechin[56].

3.3 Nano phytosomes

The use of phytoactive components in meals and food beverages is accompanied by a number of issues. One of the newest and most appealing ways to distribute botanical-based nutraceuticals is through nano-phytosomes, which are lipid-based nano-carriers. Even though nano-phytosome technology was created for medicinal uses, it might also be applied to food products to create unique functional foods and beverages[57]. Phytosomes are microscopic, cell-like structures created when lecithin, a dietary phospholipid matrix, is mixed with solids derived from plant extract. Because of their amphiphilic nature and phospholipids' emulsifying properties, phytosomes increase the bioavailability and absorption of phytoconstituents. When herbal extracts were administered as a phytosome formulation, the biological activity of the active ingredients in those extracts increased. Because of their predictable release pattern, phytosomes also aid in lowering dosage and increasing the time of action of the active components contained in herbal extracts[58]. Green tea extract has a significant anti-inflammatory effect, according to in vivo studies by Shariare and colleagues[59].

CONCLUSION

Epigallocatechin gallate (EGCG) has a variety of health-related fields, including its impact on viral infections, cancer, neuroprotection, antioxidant activity, and diseases like diabetes and obesity.

It also show effect on tumour growth inhibition, induction of cancer cell death, and metastasis suppression have been thoroughly investigated. It is a potential medicine for the treatment and prevention of cancer. EGCG has been studied for its antiviral effects in relation to viral infections. It has demonstrated antiviral action against several viruses, including the HIV virus. Additionally, EGCGs have neuroprotective effects against conditions like Parkinson's and Alzheimer's. It has shown promise for lowering oxidative stress, stopping protein misfolding, and controlling neuroinflammation.

EGCG has also been studied in the context of diabetes and obesity. It has been shown to have effects on insulin sensitivity, adipocyte differentiation, and glucose metabolism, pointing to possible advantages in the treatment of issues associated with diabetes and obesity. In conclusion, the fascinating features of EGCG make it a substance with potential therapeutic uses in cancer, viral infections, neuroprotection, antioxidant support, and metabolic diseases. By working in synergy with other therapeutic drugs, EGCG can actively engage in nanodelivery systems. By adding EGCG to nanoparticles, for instance, chemotherapeutic medications can more effectively treat cancer when their anticancer properties are increased.

More research is needed to completely understand its mechanisms of action and to optimize the formulation parameters, evaluate long-term safety, and establish the efficacy of EGCG-loaded nanoformulations to determine its clinical utility in various health conditions.

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