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Green coffee bean seed and their role in antioxidant–A review

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Abstract

All around the world, Coffee place an important position in the beverages. It contains phenolic acid as well as polyphenols. It has the property of antioxidant; mood enhances mood, and also increases alertness, reduces weight, efficiency against hypertension, and antitumor property because of its polyphenols and phenolic constituents. Chlorogenic acids (CGA) are the main components found in the fraction of phenols from green coffee beans. CGA has several therapeutic properties, which include antioxidant activities and also has hepatoprotective, hypoglycemic, and antiviral properties. Several essential compounds found in CGA in green coffee beans are caffeoylquinic acids, caffeoylquinic acids, feruloyl quinic acids, p-coumaroylquinic acids, and quinic acid. Therefore, this review highlighted the health benefits and anticancer activities of Green coffee bean.

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INTRODUCTION

In India, the customary systems of medication practiced, such as Unani and Ayurveda, drugs of plant sources have been practicing from olden times. The drug which is taken from herbal origin offers a stable market throughout the globe, and herbal plants proved to be an important origin for novel drugs (Joy *et al.*, 2001). In the pharmaceutical industry, phytochemicals play an indispensable part over ancient times. Herbal plants in pharmacology play a stirring and denoted scientific research in the phytochemicals and their biological activities (Amudha and Vanitha, 2017). Secondary metabolites are abundant in herbs with different structural arrangements and properties along with multiple pharmacologic properties. Examples of phytochemicals like saponins, phenols, flavonoids, phenolic glycosides, etc., (Hemalatha *et al.*, 2017a). Extracts from food sources like fruits, vegetables, and beverages like tea and coffee prove to be more effective.

From the genus *Coffea,* coffee bean berries are isolated. The beverage coffee started all over the globe before the 1700s. The name 'ancient wonder drug' is given to coffee for its powerful physiological effects .Throughout the globe, the largely traded agricultural product is Green coffee beans. In the majority of the tropical and subtropical countries, Coffee is the main export products (Lashermes *et al.*, 2008). An alkaloid named caffeine generally seen in beverages like tea, coffee, and cola drinks (Raeessi *et al.*, 2014). A complex mixture of nutrients like lipids, carbohydrates, minerals, vitamins, and nitrogenous compounds are rich in coffee and also rich in bioactive compounds like cafestol and kahweol diterpenes, caffeine, and chlorogenic acid (Akash *et al.*, 2014).

Throughout the globe, cancer is the most important cause of death, which has raised the attention to the search for an effective and novel therapeutic drug for the treatment of cancer. Treatment involves

surgery, and chemotherapy is the main procedure following, but it has adverse side effects with low cure rate and high secondary failures. So the scientists researched effective anticancer drugs with less toxic effects (Li *et al.*, 2016). Phytochemicals from plants used as an alternative drug for cancer treatment along with chemotherapy (Amudha and Vanitha, 2017) Plants sources play a great role, and many plant-derived compounds like polyphenols, flavonoids, and terpenoids are of much nutritional and health benefits and immensely studied for their potent useful effects on humans (Pan *et al.*, 2008). In antioxidant resistant mechanism, natural antioxidant plays a major role and has the property of scavenging the free radicals (Amudha and Vanitha, 2017). When plant foods are consumed, the bio-availability of plant extracted compounds from our plant foods may exhibit a large quantity of essential bioactive compounds (Pandey and Rizvi, 2009).

Recent studies found that the immune system is enhanced by the phytochemicals, which prevent the DNA from damage and also repairs the DNA and reduces the cells from oxidative damage and control the hormones intracellular signaling and the insulin receptors are also activated. Drugs from phytochemicals are said to be safe and very effective. Currently, research is of more importance in finding more phytochemical components from medicinal plants and also their biological activities (Varadharaj and Muniyappan, 2017). The consumption of coffee was shown to exert greater influence on the reduction of colorectal cancer. A case-control study reveals that moderate coffee consumption reduces the incidence of hepatocellular carcinoma (Akinyemi *et al.*, 2005).

MATERIALS AND METHODS

The unroasted coffee seeds (beans) are said to be Green coffee beans (GCB) of *Coffea* fruits. The process of roasting decreases the quantity of chlorogenic acid in the coffee beans. Hence when compare to roasted coffee beans, GCB beans have maximum amounts of Cholorogenic acid. In GCB, the CGA plays a significant function in medicinal properties, and-Figure 1 shows the structure of GCB.

Morphology

In the international trade market, Coffee is an economically important commodity traded in the name of green coffee (Wintgens, 2009). There are around 100 varieties are of *Coffea* genus available, among that *C. canephora*, and *C. arabica* is an essential type for trading purposes. Ethiopian mountains are the native forest of the coffee plant, which is a shrub type. It has a petite inflorescence with white & bisexual flowers known as glomerule. Fruits come under drupe, contain smooth exocarp, pulpy mesocarp, and fibrous endocarp surround the seeds known as coffee beans. During the last stage of development, the color of exocarp changes from yellow to red. Water, reducing sugars, and sucrose are present in the mesocarp. The hard endocarp protects the coffee seeds against the gut of digestive enzymes of frugivorous animals, which are shown inFigure 2 , (Castro and Marraccini, 2006).

Bio-Constituents 0f GCB

Both volatile and non-volatile compounds are present in the green coffee beans, such as to deter and caffeine. Both non-volatile and volatile compounds give the aroma flavor when roasted the coffee bean. Carbohydrates and Non-volatile nitrogenous compounds are the major compounds essential in biological activity as well as in bringing the aroma of roasted coffee.

Non-Volatile Alkaloids

Both in green coffee beans as well and roasted coffee beans, Caffeine (1,3,7-trimethyl-xanthine), the prominent alkaloid is seen on an approximate of 2.5%. During maturation also, the quantity of caffeine does not change. There are some non-volatile alkaloids too found in lower amounts, which include theobromine, methylliberine, theophylline, libertine, and paraxanthine. An alkaloid, xanthine, which is odorless and found bitter taste in water (Clifford and Kazi, 1987).

Amino Acids and Proteins

In GCB, 8% to 12% of proteins are present, and the maximum of the proteins are of 11-S storage kind, which comprises α component 32kDa & β component of 22kDa, while maturation of green coffee beans, majority of the component degraded to free amino acids. On the roasting temperature, the storage proteins (11-S type) are changed to their respective amino acids, which give bitter components because of the Maillard reaction (Montavon *et al.*, 2003). CGA and their derivatives accelerate the degradation process. Polyphenol oxidases and Catalase are enzymes which are essential proteins for the maturation of green coffee beans. Free amino acids are seen in mature GCB, for example in *Coffea robusta*, the quantity of amino acid is 4mg/g, in that the amount of alanine is 0.8 mg/g & asparagine is 0.36 mg/g whereas in *Coffea arabica* the quantity of amino acid is 4.5mg/g in that the highest concentration of alanine is 1.2mg/g and asparagine is 0.66mg/g (Murkovic and Derler, 2006).

Carbohydrates

Polysaccharides include cellulose, galactomannan,

and arabinogalactan dominate 50% of dry contents in carbohydrates of GCB, which gives the tasteless flavor of green coffee. The molecular weight of arabinogalactan is on average 90 kDa - 200 kDa and makes up to the dry weight of 17% in GCB and composed of β1-3 linked galactan main chains, with members of side chains of arabinose and galactose residues, which comprises the immunomodulating properties which by accelerating the cellular defence organization of the body. While converting the mature brown beans from yellow coffee bean contains fewer residues of galactose and arabinose, which makes the green coffee bean maximum resistant to physical breakdown and less soluble in water ((Redgwell *et al.*, 2003). Arabinogalactan with high molecular weight compounds improves the digestive tract cellular defense system rather than other plants (Gotoda *et al.*, 2006). Free monosaccharides are seen in mature brown to yellow-green coffee beans. In Arabica green coffee beans, monosaccharide contains sucrose approximately 9000 mg/100g, whereas, in Robusta, it is only 4500 mg/100g. In Arabica green coffee beans, free glucose around 30 - 38 mg/100g, free fructose around 23-30 mg/100g, free galactose around 35 mg/100g, and mannitol 50 mg/100g are the contents present respectively. Mannitol is a powerful scavenger for hydroxyl radicals generated during the lipid peroxidation in biological membranes .

Lipids

Oleic acids, arachidic acid, linoleic acids, triglycerides, esters, amides, palmitic acid, stearic acid, and diterpenes are usually seen in green coffee bean seeds. In GCB, lipid content is approximately 11.7-14g/100g, and they are originating in the inner matrix and also on the exterior. Derivatives of carboxylic acid-5-hydroxytryptamine with an amide bond to fatty acids are present on the exterior, which protects the inner matrix against oxidation and insects. And also, such molecules have antioxidant properties due to their chemical structure (Clifford and Kazi, 1987). Triglycerides, linoleic acid, palmitic acid, and esters are the lipids that are seen in interior tissue. The lipid content is higher in coffee beans of Arabica, which is 13.5-17.4 g/100g, whereas, in robusta coffee, it is 9.8-10.7 g/100g. On the whole of the lipid fraction, the diterpenes comprise around 20%. Diterpenes, which include cafestol, kahweol, and 16-O-methylcafestol, are seen in GCB (Lee and Jeong, 2007).

Volatile Compounds

Aldehydes, aromatic molecules with nitrogen content, and its derivatives like pyrazines and short-chain fatty acids are the volatile compounds generally present in GCB. In green coffee beans, the pleasing odor is less due to the presence of volatile compounds when compared to roasted coffee. Caffeine is primarily separated from the green coffee beans for commercial purposes; however, the steeped liquid is not used from the coffee beans. Nearly one hour is the recommended time for steeping for a pleasant taste.

Compounds with unique, pleasant aroma are generated of green coffee beans during the process of roasting, whereas the aroma is not seen in fresh GCB. The majority of unpleasant tasted volatile compounds are neutralized while roasting the GCB. However, the other essential molecules in GCB, like antioxidants and vitamins, are also destroyed. Nauseating odor for humans in volatile compounds has been found which includes acetic acid has pungent and unpleasant odor, propionic acid has odor of sour milk or butter, butanoic acid has rancid butter odor around 2mg/100g found in green coffee beans, pentanoic acid has unpleasant fruity flavor around 40mg/100g seen in GCB, hexanoic acid has fatty-rancid odor, heptanoic acid has fatty odor, octanoic acid has disgusting oily rancid odor, nonanoic acid has gentle nut-like fatty odor, decanoic acid has sour repulsive odor, acetaldehyde has pungent-nauseating odor, propanal has unpleasant effect on respiratory system, butanal has nauseating effect which comprises 2-7mg/kg in dried GCB and pentanal has very foul nauseating effect (Ivon, 2001).

Traditional Significance

In herbs, nearly all the parts have medicinal properties that are used in the conventional method of medicine (Amudha and Vanitha, 2017). In Chinese medicine, Coffee (C*offeearabica* and *Coffee robusta*) has been categorized as an established source of therapeutic purposes. According to the medicinal system of the Chinese –dietary system, owing to the caffeine content of the green coffee beans was comes under medicinal herb, which regulates liver qi(energy), potent energy.

In the Indian Material Medica of 1908, several health aspects of coffee beans have been reported. Recent studies show that average amount of drinking the coffee may decrease the menace of colon cancer roughly about 25%, gallstones by about 45%, liver cirrhosis by about 80%, and Parkinson's disease roughly about 50% to 80% (Dellalibera *et al.*, 2006).

Biological Significance

Green tea, like an extract from the green coffee bean, paved great attention to the researchers with increasing researches as possible health-enhancing compounds recently. Chlorogenic acids are rich in

GCB. Dicaffeoylquinic acids (CQA), as well as Caffeoylquinic acids (CQA), are the major CGAs seen in green coffee beans. They have potent antibacterial and anti-inflammatory activities (Xu *et al.*, 2010). Pre-clinical trials have proved the obesity and diabetes approaches of CGA and the therapeutic effects of green coffee bean extracts (Dellalibera *et al.*, 2006). On consumption of CGAs, diverse health benefits are reported, such as decrease the possibility of Alzheimer's disease, diabetes type 2, and cardiovascular problems ((Salazar-Martinez *et al.*, 2004). Metabolic syndrome and their associated disorders are preventable by the chlorogenic rich food supplements, and it was proven through *in vivo* studies and also in clinical trials, and their mechanism of action also reported (dos Santos *et al.*, 2006).

Chlorogenic acid shows diverse health benefits, which include treatment of chronic myelogenous leukemia, breast cancer, colon cancer, hepatocellular carcinoma, brain tumor, and lung cancer through pre-clinical & clinical studies phase I (Bandyopadhyay, 2004). But still, the role of chlorogenic acid in the mechanism of action of the molecules for the anti-cancer activity remains blurred and must to be clarified. Green bio compounds isolated from unroasted coffee beans were indeed responsible for the anticancer property (Rao and Nadumane, 2016). Tocopherols, sterols, triglycerols, and diterpenes are the main compounds in the green coffee bean lipid fractions (Speer and Kölling-Speer, 2006).

Phytoconstituents of GCB

Catechol groups, which are seen in non-flavonoid compounds, are become special interest recently due to their medicinal and pharmacokinetic activities (Santos *et al.*, 2005). Secondary metabolites from herbs, especially polyphenolic compounds, play a special role in defense against pathogens. Polyphenols from plants are abundantly found in our dietary food, which shows various important bioactivities having health benefits (Pandey and Rizvi, 2009).

Polyphenols are abundantly present in beverages as well as foods that prevent various kinds of disorders associated with oxidative stress, cardiovascular disease, and also different cancer types (Matsunaga *et al.*, 2002). Antioxidants and phytochemicals are abundantly seen in plants and microorganisms, which contains various health beneficial effects. From plants, various kinds of anti-cancer drugs are derived. In coffee, more abundant polyphenolic constituent are 3-, 4- and 5-Caffeoylquinic acids, which account for up to 30 mg/g coffee (Priftis *et al.*, 2018). Secondary metabolites from plants are concerned in defense against ultraviolet radiation, climatic conditions, or destroying the pathogens (Farah and Donangelo, 2006).

Major polyphenols from green coffee beans are hydroxycinnamic acids and quinic acid, together known as chlorogenic acids (Clifford and Kazi, 1987). Tannins, anthocyanins, and lignans are seen in seeds in fewer amounts. Polyphenols from coffee are excellent antioxidants and possess free radical scavenging properties (Yashin *et al.*, 2003). Amino acids conjugate with hydroxycinnamic acids called as cinnamoyl amides or glycosides known as cinnamoyl glycosides, which are seen in green coffee and possess good antioxidant property (Alonso-Salces *et al.*, 2009).

Biological Properties Of Phytoconsitutuents

Polyphenols are found in nearly all the diet, which we are taking that contains various medicinal values that came to attention to the scientists in the past few decades. Several health benefits of polyphenols which includes antioxidant, anticancer, and anti-inflammatory properties . *An Invivo* research also highly proves the function of polyphenols in preventing cardiovascular diseases. The growth of atheromatous lesions reduces by inhibiting the process of oxidation of low-density lipoprotein by the intake of polyphenols (Marrugat *et al.*, 2004). *In vitro and in vivo,* researches showed that polyphenols have anticancer activity (Li *et al.*, 1999).

Figure 1: Structure of a GreenCoffee Bean

Chlorogenic Acid

In coffee, an alkaloid named as caffeine, which is the compound most widely studied component of coffee. However, caffeine alone is not the sole bio-active compound of coffee. Chlorogenic acids are the most important isomer, which contributes to its valuable and potent antioxidant activities (Murthy and Naidu, 2012).

C_{16} $(H_2O)_9$) is the molecular formula for chlorogenic acid and formed from caffeic and quinic acidsFigure 3 , (Toyama *et al.*, 2014). Both the aliphatic and the aromatic groups are seen in it. In green

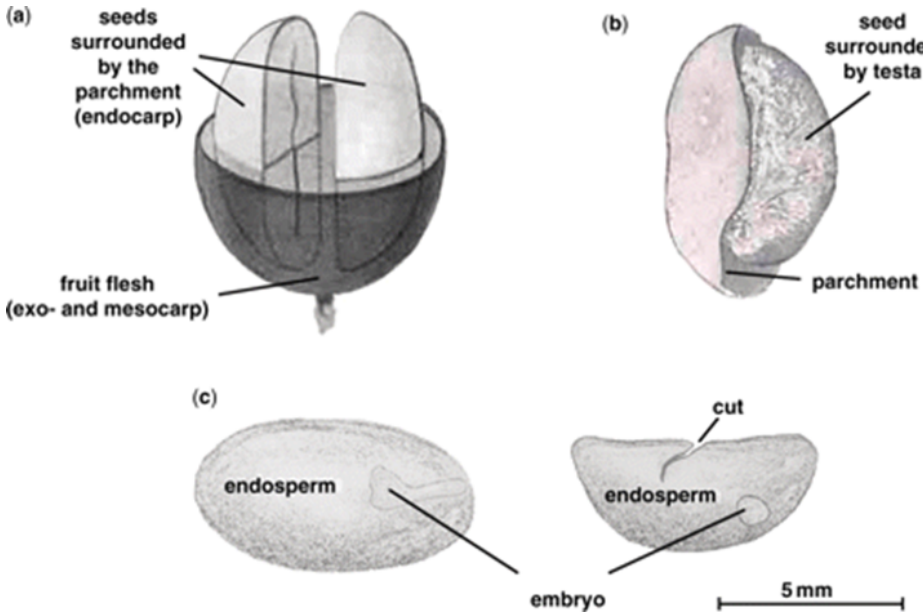

Figure 2: Seed and Fruit Morphology - *Coffea Arabica*

coffee beans and tobacco leaves, CGA, an important polyphenolic component, is found (Ostergaard *et al.*, 2013). In the human diet, as the polyphenols are abundant in chlorogenic acids, which was proved to inhibit cancerous cell growth (Park *et al.*, 2015). Among dietary sources, Coffee plays a major nutritional source of CGA, which accounts for a range from 70 to 350 mg / 200 ml of coffee (Burgos-Morón *et al.*, 2012).

Biological Properties Of CGA

Chlorogenic acid has potent antioxidant properties (Onakpoya *et al.*, 2011). CGA may be a potential novel medicinal option for curing the lung cancer. In tumor angiogenesis, the effect of CGA is good, but the mechanisms of action are yet not found (Farah and Donangelo, 2006). Apart from antioxidant properties, CGA has other important medicinal values, which include anti-inflammatory, antiviral, hypoglycemic, and hepatoprotective properties (Marinova *et al.*, 2009) . Recent studies show that CGA has potent antiproliferative activity, and it has the capability to persuade the process of apoptosis and damage the cellular DNA without affecting the fibroblast of normal lungs in the cells of lung cancer.

CGA also may prevent diabetes and cardiovascular problems. Patients those who are with viral hepatitis who drank coffee every day experienced a diminution in the frequency of HCC because of the antioxidant capacity of CGA (Arab, 2010). Green coffee beans have a compound CGA7, which induces the process of cell death via apoptosis and also inhibits colon cancer. Therefore CGA7 can be capable of potent dietary as well as chemopreventive and curative agents for cancer prevention.

Extract from *Achillea tenorii* possess flavonoids and caffeoylquinic acids and which possess antioxidant properties, as well as free radical scavenging activities, also found in the *Hypericum hircinum L*. extract which possesses CGA. An essential oil from *Stachys palustris* possesses caffeoylquinic acids, which has radical scavenging activity. Phenolic acids and their hydroxyl groups are capable of act as optimistic moieties for its antioxidant activity. CGA has potent antioxidant activities which also reported in docking studies, and fruits of *Angelica Officinalis L* also contains an abundant amount of CGA (Naveed *et al.*, 2018).

Oxidative stress and oxidative damage are increases due to the pathogens which cause diseases and are cured by CGA, which has a significant electrophilic trapping agent and also shows strong exploit on lipid peroxidation. By declining the levels of 3-nitrotyrosine and 8-isoprostagland in F2α, CGA protects the damages caused by the free radicals. When compared to *N*-methylpyridinium-rich coffee, the CGA rich coffee prevents the oxidative DNA damage much more (Tajik *et al.*, 2017). In carcinogenesis, related genes which show abnormal expression plays a vital role in the mechanism (Hemalatha *et al.*, 2017b). The potent inhibitory action of phenolic compounds inhibits the mechanism of carcinogenesis.

CGA has a potent chemopreventive property that protects colon cancer in the rat model. In rats, oral cancer, which is induced by 4-nitroquinoline-1-oxide, is inhibited by CGA and also inhibits the liver cancer in hamsters. Inhibitory effects of CGA on the tumor in the skin of the mouse were less effec-

tive when compared to curcumin. Glandular stomach cancer induced by *N*-methyl-*N*-nitrosourea is suppressed by CGA, which shows an imperative feature for research in preventing human stomach cancer (Tajik *et al.*, 2017). In preventing the oxidative damage and aging-related disorders, the process of reactive oxygen species is inhibited by the CGA, and therefore, it serves as good scavengers (Kweon *et al.*, 2001).

Properties Of Roasted Coffee Bean

The normal process of roasting the coffee seeds may adversely affect the coffee's composition and bioactivity component properties. Numerous observations confirmed that the process of roasting the coffee seeds which affects the chlorogenic acids that leads to the breakdown and development of novel compounds, which may also modify the strong antioxidant activities of coffee beans (Jaiswal *et al.*, 2012).

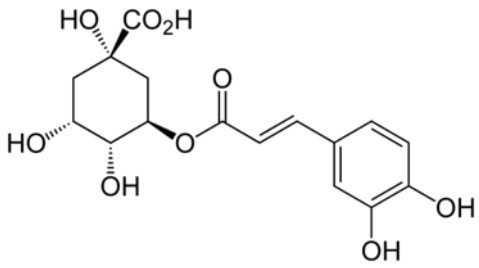

Figure 3: Structure of Chlorogenic Acid

CONCLUSIONS

Green coffee beans are more beneficial to health rather than coffee as a drink, which may have negative effects due to multiple bioactive components. Further purified and studied the green fraction can be a basis for the novel anticancer lead molecule.

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