The black tea bioactivity: an overview

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Abstract

Tea is one of the most popular beverages in many countries and is the second, after the pure water, most consumed drink in the world, but consumption habit varies between different countries. Incidence of different diseases varies widely across the world and many investigators relate these differences to diet including habitual tea drinking. It is consumed mostly as green tea and black tea where other forms such asoolong; red or white teas are less popular. Green tea was extensively investigated on its health benefits but black tea is only now catching the serious attention of scientific community. Compounds contained in black tea such as theaflavins and thearubigens contribute to black tea dark color and distinctive flavor. They also provide health benefits originally attributed solely to green tea. This review summarizes available information on bioactive ingredients of tea, their bioactivity and relation to diseases, bioavailability with special attention to health benefits of black tea.

Key words: black tea, polyphenols, bioavailability, cancer, cardiovascular.

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Tea is the second, after the pure water, most consumed drink in the world. It is one of the most well-liked beverages in many countries. Among other popular drinks it contains the highest concentrations of minerals and antioxidants. The real teas are produced from the same species of the plant Camellia sinensis. There are four types of basic teas: unfermented green tea, fully fermented black tea, red tea which is partially fermented oolong tea and white tea from tea leaf buds. Approximately 20% of the world’s consumption is in the form of green tea, and other 80% are black and oolong teas [1]. Tea is grown in about 30 countries but as a popular drink it is mostly consumed in Asia and Europe, less in North America and North Africa (mainly Morocco). Green tea is popular in whole Asia while oolong is mostly drank in China and Taiwan [2].

Bioactive ingredients of fresh leaves and green tea

Fresh leaves of tea contain on average: 36% polyphenolic compounds, 25% carbohydrates (pectins, glucose, fructose, cellulose), 15% proteins, 6.5% lignin, 5% minerals and trace elements (magnesium, chromium, iron, copper, zinc, sodium, cobalt, potassium, etc.), 4% amino acids (such as theanine [5-N-ethyl-glutamine], glutamic acid, tryptophan, aspartic acid) 2% lipids, 1.5% organic acids, 0.5% chlorophyll as well as carotenoids and ethereal substances below 0.1%, vitamins (B, C, E) [3]. Green tea leaves are pan-fried or steamed, which prevents different bioactive compounds, like many polyphenolic flavonoids, from being oxidized. An average serving of green tea is brewed of 2 g of leaves in ~200 ml of hot water and contains approximately 600-900 mg of water extractable solids including tea catechins (30-40% by weight). The rich content of catechins representing approximately 90% of the polyphenolic fraction in green tea (considerably more than in black tea) is believed to generate its pro-health effects (Table 1). Tea catechins appear as isomers trans-catechins and cis-catechins depending on the stereochemical configuration of the 3’,4’-dihydroxyphenyl and hydroxyl groups at the 2- and 3-positions of the C-ring [4]. Main catechins found in green tea are: catechin (C), gallocatechin (GC),
epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), epigallocatechin gallate (EGCG). In addition, green tea contains alkaloids (caffeine) and other flavonoids such as quercetin, kaempherol, and myricetin [5-7]. Epigallocatechin gallate was the most extensively studied active component of green tea and is known for its anti-cancer properties and potent antioxidative effect. It is a stronger antioxidant than either vitamin C or E.

Bioactive ingredients of black tea

There are various types of black tea, mostly named after the geographical region they came from. Assam tea is named after Assam, the region in India. It brews as burgundy red with rich aroma and a strong, malty taste. Yun- nan tea is produced in Yunnan region of China. It is char-

Table 1. Content of different polyphenols in green and black tea (µg/ml) [13]

<table>
<thead>
<tr>
<th>Compound</th>
<th>Green tea (µg/ml)</th>
<th>Black tea (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>catechin (C)</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>(-)-epicatechin (EC)</td>
<td>98</td>
<td>37</td>
</tr>
<tr>
<td>(-)-epicatechin-3-gallate (EGC)</td>
<td>90</td>
<td>73</td>
</tr>
<tr>
<td>(-)-epigallocatechin (EGC)</td>
<td>411</td>
<td>42</td>
</tr>
<tr>
<td>(-)-epigallocatechin-3-gallate (EGCG)</td>
<td>444</td>
<td>128</td>
</tr>
<tr>
<td>Total catechins</td>
<td>1064</td>
<td>380</td>
</tr>
<tr>
<td>theaflavin (TF1)</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>theaflavin-3-gallate (TF2a)</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>theaflavin-3’-gallate (TF2b)</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>theaflavin-3,3’-digallate (TF3)</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Total theaflavins</td>
<td>0</td>
<td>64</td>
</tr>
</tbody>
</table>

Fig. 1. Conversion of catechins of green tea to theaflavins and thearubigins of black tea [1]
characterized by malty and peppery flavor. Darjeeling tea coming from the Darjeeling region in West Bengal, India is famous for its light-color floral aroma with tannic characteristics.

Nilgiri tea grows in the hills of the Nilgiri district of Tamil Nadu in India. It is very aromatic with a distinct briskness and a tantalizing flavor. Ceylon tea is cultivated in Sri Lanka (formerly Ceylon). It is known for its citrus taste and therefore is available in pure but also blended form [8, 9].

The tea fermentation process allows the leaves to undergo enzymatic oxidation when polyphenol oxidase causes polymerization of flavan-3-ols to catechin oligomers – bisflavanols, theaflavins, thearubigins and others. As a result only ~15% catechins from green tea remain unchanged, the rest is transformed to theaflavins and thearubigins [1] – see Fig. 1. Hence, in contrast to green tea with yellowish-greenish hues, fully fermented black tea has a dark brown hue and a sweet aroma of malt sugar.

The typical black tea brew is composed of number of small molecules, mostly alkaloids (e.g. theobromine and caffeine), carbohydrates and aminoacids (including theanine) as well as glycosylated flavonoids, together accounting for 30-40% of the dry weight. The remaining 60-70% consists of poorly characterized polyphenolic fermentation products, in that number oxytheotannins further subdivided into theaflavins and thearubigins. Theaflavins (a mixture of [theaflavin-3-gallate, theaflavin-3'-gallate and theaflavin-3,3'-digallate] possesses benzotropolone rings with dihydroxy or trihydroxy aromatic moieties as substituents and a characteristic yellow-orange color [10]. The red- or dark brown thearubigins consist of more than 5000 individual compounds retaining chiral properties of flavanols and theaflavins while prone to aggregation in aqueous solution. Their structures and bioavailability are still not well characterized [11]. Theaflavins and thearubigins account for 3-6% and 12-18% of dry weight of black tea and contribute to its strong, bitter flavor and characteristic dark color [12]. Comparison of a content of the basic compounds in crude black and green tea extract is given in Table 1 [13].

During the production process as much as 75% of catechins from tea leaves undergo oxidation and partial polymerization due to the enzymatic processing by polyphenol oxidase and other endogenous enzymes. Therefore, the final black tea composition considerably depends on the processing technology.

In average expected composition of black tea solid extract includes: catechins (10-12%), flavonols (6-8%), theaflavins (3-6%), thearubigins (12-18%), phenolic acids (10-12%), amino acids (13-15%), methylxanthines (8-11%), carbohydrates (15%), proteins (1%), and minerals (10%). The most important flavonols in black tea are myricetin, quercetin, kaempferol and rutin, similar as in green tea. Black tea also contains phenolic acids, caffeine (about one third the amount typical for coffee) and amino acids including theanine (5-N-ethyl-glutamine) which occurs only in the tea leaves [3].

Theanine (γ-glutamylethylamine) is a compound unique for tea accounting for almost 50% of its aminoacid content as well as unique “brothy” taste. It is known for considerable neuroprotective effects and cognition enhancing properties, assists in brain function development i.e. central nervous system maturation [14]. Theanine was also shown to act as an neurotransmitter, modulator of serotonin and dopamine levels enhancing memory and learning abilities [15]. Importantly enough theanine plays its positive role in attentional processing in synergy with caffeine [16].

Black tea bioactivity – known facts

The impact of green tea, in particular its flavonoids and catechins, on the oxidant-antioxidant balance has been extensively studied. Their antioxidative properties are recognized and mostly attributed to the ability to inhibit free radical generation or biological activity activity as well as to chelate transition metal ions, mainly Fe and Cu catalyzing the free radical reactions.

On the other hand little is known about more complex compounds formed from catechins during natural fermentation in the process of black tea production [2, 17]. While catechins represent ~90% of phenolic fraction in green tea, in black tea brew only ~15% of them remains not oxidized. Still, black tea is a valuable source of polyphenols, majority of them belonging to oxytheotannins, represented by theaflavins and thearubigins. Rechner et al. have shown that a cup of black tea delivers on average ~260 mg of polyphenols of which ~220 mg stand for theaflavins and thearubigins. Authors researched seven different brands of black tea marketed in England showing that each contained similar combination of polyphenols dominated by thearubigins (75-82% of total polyphenols) and followed in a decreasing order by theaflavins, flavan-3-ols, flavonols, gallic acids and hydroxycinnamates [18]. Among them epigallocatechin gallate, four theaflavins, epicatechin gallate, quercetin-3-rutinoside, 4-cafeoylquinic acid were clearly and theogallin tentatively identified, with the total of 20 polyphenols as quantified by HPLC analysis. The antioxidant activity was assessed independently by three different methods (Trolox Equivalent Antioxidant Capacity – TEAC, Oxygen Radical Absorbence Capacity – ORAC, Ferric Ion Reducing Antioxidant Power – FRAP) showing good correlation in-between the methods as well as corresponding with previously published studies that characterized oxytheotannins as effective scavengers of free oxygen (superoxide anions, singlet oxygen) and nitric (nitric oxide, peroxynitrite) reactive oxygen species (ROS). Interestingly, theaflavins being dimers contain more hydroxyl (OH) groups than catechins, and this structural detail is pivotal for radical scavenging abilities. As a result, some
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theaflavins, like TF3 reveal higher antioxidative activity than EGCG, the strongest antioxidant among catechins. Also, it was demonstrated that theaflavins react over 10 times faster with superoxide radical than EGCG [3].

Beside free radicals scavenging theaflavins antioxidant properties are attributed to their ability to inhibit pro-oxidant enzymes and form stable complexes with iron or copper ions, therefore preventing free radical generation and lipid peroxidation. Yet, the concentration of black tea polyphenols in human blood even after considerable tea ingestion is 100-1000 times lower than the circulating amounts of other physiological antioxidants, like ascorbic acid or glutathione. That fact provokes the question about the practical meaning of the abovementioned antioxidative activity of black tea. Does it really induce any meaningful effects in vivo?

The increased antioxidant activity has been observed in laboratory animals exposed to the prolonged black tea enriched diet. In humans however, results were somewhat diverse. The ex vivo studies clearly confirmed the scavenging properties of black tea and catechins towards human cells. Interestingly, black tea extract in comparison to catechins exerted higher protective effect towards various types of oxidative stress [3, 19]. The iron chelating activity of tea polyphenols is a well proven fact. They avidly interact with iron ions forming the insoluble complexes, black tea more than the non-fermented green tea. This process inhibits haem absorption in the gastrointestinal tract, though involves the non-haem iron only and might be reversed in the presence of the ascorbic acid. It is not clear to what extend this phenomenon is responsible for the antioxidative activity of black tea in the real-life setting, however definitely affects the balanced iron turnover.

However, good quality data on the comparison of the antioxidative capacity of black and green tea are somewhat contradictory concluding that black tea activity is higher, on par or diminished in relation to green. Prior and Cao compared eighteen green and black tea brands from different sources demonstrating that an average antioxidative capacity (ORAC) and total phenolic content for the black tea is clearly higher than for green one [20]. Alternatively, Benzie and Szeto evaluated 25 blends of local Hong Kong tea by FRAP method concluding that green had the highest antioxidan potential while black and oolong tea were similar and less potent in that respect [21]. Still, when green tea was evaluated against black tea of the same brand (Assam from India) thus eliminating possible discrepancies due to the different plants, environmental factors and production site, no considerable differences in TEAC potential were observed [22]. Consequently, it should be accepted that ROS scavenging potential of black tea differs for different commercial brands, solidly depending on geography and technology of production. Thus, results from any clinical studies in humans strongly depend on local circumstances. Positive impact of black tea polyphenols on consumer health seriously depends on people overall metabolism but also bioavailability of their metabolites [18]. Xie et al. signalized that flavanols and other constituents of black tea in a pure form are not only strong antioxidants but also the effective lipoxygenase inhibitors [23]. It is worth noticing that human oxygenases are responsible for fatty acids peroxidation in a submembrane environment of cells, clearly related to ROS, ubiquitous in the body and implicated in many human diseases (inflammatory, cardiovascular, cancers, neurological disorders). Halder and Bhatduri studied black tea extract as possible preventative of oxidative stress provoked in human blood by different inducers. They have found that black tea or its chosen components could avert lipid peroxidation, degradation of membrane proteins and reverse membrane fluidity to full restoration of its architecture. In their experiments black tea extract was performing better than individual catechins proving that theaflavins and thearubigins which dominate in black tea brew are just as effective or better than smaller and simpler catechins [19].

Bioavailability of black tea components: problems and promises

Extensive data indicate that bioactive components of black tea might be quite important for prevention of considerable number of disorders. While abovementioned studies on black tea components seem to strongly support that view, their bioavailability analysis points at its possible flaws. The relatively high molecular weight, low internal activity, poor absorption, high rate of metabolisms, and rapid inactivation of metabolism products are considered the most important reasons for rather low bioavailability of black tea polyphenols. It is also affected by the fact that phenolic OH groups tend to form large hydration shells [24]. On the other hand Rechner et al. elegantly proved that incubation of the black tea brew with the simulated gastric acids significantly increased content of the theaflavins (140%). It was attributed to the cleavage of the thearubigins at low pH into smaller and therefore more readily absorbed theaflavins [18]. Some authors have also suggested the possibility of the prolonged colonic metabolism of black tea polyphenols, theaflavins and thearubigins [25]. Warden et al. quantitatively evaluated bioavailability of black tea catechins in healthy volunteers demonstrating their peak in the plasma 5 hours after ingestion, with only 1.68% of their total intake present in the blood, urine and feces [26]. Catechins were present in the blood for 24 hrs after single intake of tea. Interestingly, several studies demonstrated different bioavailability of gallated and nongallated forms, but their conclusions were contradictory [26-28]. In our opinion methodological issues and difficulties in exact theaflavin metabolites estimation might be responsible for those discrepancies. Detection of theaflavin metabolites with the modified A and C ring only, could not
be considered adequate and reliable measure of their bioavailability [28, 29].

However, Leenen et al. have shown that antioxidative potential of plasma after black tea ingestion was not different to that observed after green tea, irrespective of the dissimilar catechin levels, confirming the suggestion of their rapid absorption from the gastrointestinal tract [30]. Similarly, the theaflavin and thearubigin fractions of black tea strongly inhibited human recombinant sulfotransferase SULT1A1 and SULT1A3 isoforms representing liver and intestinal enzymatic activity therefore affecting mechanisms regulating absorption [31].

Still, the bioavailability of theaflavins and thearubigns and understanding of their metabolism and resulting metabolites is unclear and needs further cautious evaluation. Besides, little is known about possible effects of diet on the bioavailability of tea constituents. Immense differences in regional dietary habits are rarely considered whereas might be of considerable importance, responsible for example for varying result observed in clinical studies on the health effects of long-term ingestion of black tea. Similarly, the effect of milk added to the tea brew as it is customary in UK and other Commonwealth countries should be accounted for. While milk proteins bind directly and easily to black tea catechins and flavonols, Hertog et al. demonstrated that beneficial effect of black tea consumption on the risk of coronary heart disease was not observed in subjects consuming tea with milk [32]. It is still unclear what mechanism is responsible for this effect. Both ex vivo and in vivo studies are equivocal at best.

Consequently, any studies evaluating the in vivo bioactivity of black tea or its constituents should strictly define the studied group according to demographic (race) as well as geographic criteria. Both strongly imply critical differences in tea content (black vs. green, brands of black tea) as well as consumption habits (with milk pre-boiled or fresh, with lemon, habitual diet) that might considerably affect the outcomes. This particular fallacy is unfortunately quite common. If black tea undeniable bioactivity is to be evaluated properly and relevantly exploited in humans more well designed studies are needed.

Medicinal effects of black tea

Bioactive components of the black tea brew have been attracting much attention with regard to human health. While in vitro data demonstrate quite convincingly their considerable biological activity, animal and clinical studies have been less conclusive regarding to their effectiveness and potential applicability in disease prevention or therapy (supplementary role). Still, some data provide intriguing evidence on their beneficial effects, in particular in chronic pathologies characterized by high oxidative stress.

Atherosclerosis and cardiovascular diseases

The mechanism of atherosclerosis and consequently cardiovascular diseases (CVD) involves chronic inflammation, endothelial dysfunction and metabolic imbalance. Animal studies showed that black tea consumption reduces cholesterol liver synthesis and its serum levels thrice more effective than green tea [33, 34]. Similar effect was demonstrated by placebo-controlled randomized study in humans with five servings of black tea resulting in slight drop of total and LDL cholesterol in serum of mildly hypercholesterolemic patients [35]. Vermeer et al. proved as well that black tea theaflavins, in particular theaflavin-3-gallate, might interfere with intestinal cholesterol absorption [10]. In contrast, data on the low density lipoprotein (LDL) oxidation are unequivocal. Some authors observed no protective effect of black tea [36]. Others, as Ishikawa, documented that catechins, especially EGC G, and theaflavins strongly delay LDL oxidation i.e. atherosclerosis development and progression [37]. And finally some suggested that black tea might have greater impact on the ex vivo lipoprotein oxidation that green tea [38]. As described before black tea components, like flavonoids, are reducing agents capable to effectively chelate metals involved in cellular oxidation reactions. Hence their preventive/ameliorating effect on the oxidative stress within endothelial barrier supporting the normalization of endogenous vasodilators production, restoration of physiological endothelial barrier permeability as well as down-regulation of inflammatory markers and mediators expressed by endothelial cells. Jochmann et al. proven that beneficial effects of black tea on the endothelial function, both ex vivo and in patients, were comparable to green tea [39]. Also, catechins are able to incuse cell-cycle arrest and interact with growth factor to inhibit vascular smooth muscle proliferation, a key event in the development and progression of atherosclerosis [40]. In addition, considerable effect of black tea on the metabolic and inflammatory markers represented by uric acid (UA) and C-reactive protein (CRP) was observed in controlled studies [41].

Still, epidemiological studies attempting to analyze the link between black tea consumption and risk of cardiovascular death are inconclusive. Meta-analysis of ten cohort studies and seven case-control studies performed by Peters et al. in 2001 demonstrated considerable heterogeneity preventing reliable estimation of black tea effect on the stroke and coronary heart disease incidence. Still, occurrence of myocardial infarction has been shown to decrease by 11% (relative risk = 0.89) providing that at least three cups of black tea were consumed per day [42]. Heterogeneity of evaluated data revealed by this analysis was consistent with size of the analyzed studies (smaller tending toward significant effects) and their geographical origin. On the other hand, Huxley et al. in their meta-analysis of prospective
cohort studies observed a 20% risk reduction in coronary artery disease mortality in participants within a top tertile of flavonoid intake. However, subsequent large cohort projects performed in European Welsh (n = 17 228) and Japanese groups (n = 76 970) demonstrated no significant association between black tea consumption and the risk of CVD incidence both in men and women [43, 44].

Some authors suggested that black tea polyphenols might exert positive effects in patients already treated due to CVD [45]. Duffy et al. analyzed both short- and long-term effects of black tea on the endothelial dysfunction in 50 patients with confirmed coronary artery disease and showed significant endothelium-dependent flow-mediated arterial dilation [46]. Similar effect was described in healthy volunteers [47]. Also, Hirata et al. have shown improved coronary flow velocity reserve as assessed by transthoracic Doppler echocardiography following acute black tea consumption [48].

**Acute and chronic inflammation**

Considerable evidence points at the anti-inflammatory bioactivity of the black tea polyphenols. It is warranted not only by their anti-oxidant properties. Tea polyphenols and EGCG in particular are able to selectively affect the production and/or bioactivity of pro-inflammatory cytokines (IL-1β, TNF-α, IL-6, IL-8) and mediators (iNOS, COX), mostly by modulating cellular signaling processes (NF-κB) [15]. Moreover, both black tea extract and three major black tea-derived catechins: epicatechin gallate, epigallocatechin and epigallocatechin gallate, were shown not only to suppress production of IL-1β by human leukocytes, but also to enhance synthesis of well-known anti-inflammatory cytokine IL-10 [49]. In the animal models of paw oedema black tea extracts significantly inhibited acute inflammatory response induced by number of physiological mediators (histamine, serotonin, prostaglandin) [50]. It has been repeatedly suggested that chronic persistent inflammation both low-grade as in atherosclerosis and more severe as chronic arthritis are to certain extend down-regulated by the black tea constituents. However, it should be emphasized that these effects were observed mainly at catechins concentrations hardly achievable in human plasma in vivo. Therefore the average black tea consumption is quite unlikely to exert considerable protective anti-inflammatory effect. The beneficial effect of black tea on the caries development and progression seems to be the exception. Black tea brew in standard, customary quantities appears to suppress salivary amylase activity, decrease tooth surface pH and therefore reduce the growth and virulence of periodontal microorganisms [24, 51]. Moreover, regular consumption of black tea affects dental bone density due to the higher fluoride content as the tea plant tends to accumulate fluoride from soil as well as due to other chemical tea compounds, caffeine and phytoestrogens, influence [52].

**Cancer**

There is vast literature suggesting beneficial effects of regular green tea intake on the malignancies incidence in humans including: liver, lung, stomach, pancreatic, colon, breast, oral and prostate cancer [53-58]. Still, the thorough Cochrane meta-analysis of 51 studies with more than 1.6 million participants did not provide any firm conclusions. On the contrary, it was implied that data were insufficient and inconsistent. Still, in some types of neoplastic disease as prostate or lung cancer there was moderate evidence of risk reduction shown, while in others as gastric or urinary bladder cancer no effect was observed [1]. Recent exploratory meta-analysis of 13 observational studies confirmed borderline significant association between high green tea consumption and lower prostate cancer risk, with significant ameliorating effect observed in case-control studies (OR = 0.43) [59]. Still, it should be emphasized that regulatory authorities in Europe and USA are not as yet satisfied with abovementioned evidence. Green tea is not registered or officially recommended as an effective bioactive medicinal substance.

Epidemiological data concerning black tea effects are even more scant and generally suggest much weaker effect if any. In the cited meta-analysis no statistically significant association was observed between black tea consumption and cancer risk [59]. Numbers of studies provide data on the use of green tea or green tea polyphenols to enhance the effectiveness of chemo/radiotherapy. For black tea no compelling data are available [60]. While results of epidemiological analyses are irregular, research data provide quite persuasive evidence supporting chemo preventive effect of teas, though much stronger for green than for black tea. There are multiple and quite divergent mechanisms proposed to explain anti-cancerous tea effects including antioxidant, anti-proliferative, anti-inflammatory, antibacterial and antiviral activity. Many of them are attributed to the polyphenols bioactivity, EGCG in particular. Strong radical scavengers and metal chelators exert ameliorating effect on the oxidative stress, one of the driving processes in carcinogenesis [3]. Interestingly, polyphenols induce also production of endogenous anti-oxidant molecules and enzymes enhancing physiological defense mechanisms [61]. Gutierrez-Orozco et al. showed that both, green and black tea extracts exerted down-regulatory effect on the IL-8 production and secretion by IL-1β stimulated gastric cancer cells [62]. Therefore, it was demonstrated that both teas possess anti-inflammatory activity, also toward persistently acute inflammation. Observed effect was irrespective of their different catechin profiles and mediated via inhibition of intracellular transcription factor NF-κB [62]. In this context, anti-bacterial and anti-viral properties of green and black tea flavonoids should be recalled as they provide additional defensive anti-inflammatory mechanism potentially important in the real-life setting [24]. An excellent exam-
Alzheimer’s disorders by attenuating the degeneration of dopaminergic neurons and promoting neuron survival [72, 73]. Asian cohort studies strongly support that suggestion.

How ever, human genetic heterogeneity together with cultural and life-style differences are most probably the key reasons. Described dissimilarities between European and Asian cohort studies strongly support that suggestion.

Other disorders

It was implied that antioxidant and anti-inflammatory effects of tea consumption might be useful to support pharmacological therapy of neurodegenerative Parkinson’s and Alzheimer’s disorders by attenuating the degeneration of dopamine neurons and promote neurons survival [72, 73]. In recent years, a number of experimental and observational studies in humans provided strong evidence for the positive effect of green and black teas on weight control in obese subjects [73-77]. Most likely, the underlying mechanism is very complex and still not very well understood. Still, the significant reduction of serum cholesterol both in experimental animals and humans was observed [78]. Uchiyama et al. have shown that irrespective of metabolism modification, black tea polyphenols interfere with intestinal lipid absorption [79]. Meanwhile, Chen et al. suggested their positive effect on metabolic gene expression, glucose tolerance and body composition in animals fed a high-fat diet [74]. Still, human interventional studies are positive for green tea only and mostly its extracts. Interestingly, positive interaction between tea and physical exercise in abdominal fat and serum lipid control has been suggested [75].

In summary, available epidemiologic and experimental studies showed the positive relationship between black tea consumption and prevention or possible cure of variety of diseases. However, more dose-response and mechanistic studies are needed to understand the effects of tea consumption on human ailments. Furthermore, appropriate strategies are warranted for future clinical trials transliterating animal data and small human experiments to fully proven nutraceutical.

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