

# Tea for Minds and Hearts: A Scoping Review

Dr. Emma Derbyshire<sup>1,\*</sup>, Dr. Timothy J Bond<sup>2</sup>, Dr. Gill Jenkins<sup>3</sup>

<sup>1</sup>Nutritional Insight, Epsom, Surrey, United Kingdom

<sup>2</sup>Tea Advisory Panel; Tea and Herbal Solutions; 103 Warwick Avenue, Bedford, MK40 2DH, UK

<sup>3</sup>General Practitioner (GP), Nuffield Bristol Hospital, 3 Clifton Hill, Bristol BS8 1BN, United Kingdom

\*Corresponding author: Emma Derbyshire, Nutritional Insight, Epsom, Surrey, United Kingdom, E-mail: emma@nutritional-insight.co.uk

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## Abstract

Tea is a ubiquitous and staple beverage for many people globally. It is well documented that mental well being and cardiovascular health are both recognized as being important in determining general health. The two are intricately linked as people with mental health issues are more likely to have heart disease. We systematically searched the PubMed database and selected studies by predefined eligibility criteria. The reviewed studies presented a large body of evidence indicating that black tea drinking could benefit markers of heart health, including vascular and endothelial function. There is emerging evidence that tea drinking (black and green) and aromatic inhalation of certain teas (e.g., Darjeeling and Assam teas) could aid relaxation, lower stress, dementia risk and cognitive decline and potentially improve attention and psychomotor speed in advanced age. Further human trials are warranted.

**Keywords:** Black tea; Cardiovascular disease; Cognition; Emotions; Green tea; Heart health; Mental wellbeing; Memory

**Abbreviations:** CgA: Chromogranin-A (salivary); CHD: Coronary Heart Disease; CI: Confidence Interval; COVID 19: Coronavirus Disease 2019; CVD: Cardiovascular Disease; DBP: Diastolic Blood Pressure; EGCG: Epigallocatechin Gallate; FBF: Forearm Blood Flow; FMD: Flow-Mediated Dilation; IHD: Ischaemic Heart Disease; MCE: Major Coronary Events; NF-κB: Nuclear Factor-Kappa B; NO: Nitric Oxide; OR: Odds Ratio; P: Probability; PP: Pulse Pressure; RCTs: Randomised Controlled Trials; SBP: Systolic Blood Pressure; UK: United Kingdom

## Introduction

Globally, an excess of people suffer from mental health issues contributing to one of the largest proportions of the global disease burden [1]. The world health organization now recognizes that there is “no health without mental health”, reporting that mental conditions are responsible for 30-40% of chronic sick leave and around 3% of Gross Domestic Product with action needed in this important field [2].

In the United Kingdom (UK) it was reported in 2021 that around 1 in 4 people experience mental health issues at some point in the year and 1 in 6 experienced a mental health issue weekly [3]. In total, poor mental health is projected to cost the world economy \$6 trillion by 2030 due to poor health and reduced productivity [4].

Cardiovascular disease (CVD) is a well-recognised chronic disease with pre-existing CVD now also seemingly being linked to worse outcomes and increased mortality in patients with COVID-19 [5]. Over the past two decades well established risk factors for CVD have been accruing in younger adults-poor diets, obesity and physical inactivity, alongside other temporal risk factors such as electronic cigarettes, and recreational drug use [6]. Ten predominant CVD risk factors are now well recognized which include: unhealthy nutrition, obesity, physical inactivity, and genetics e.g., familial hypercholesterolemia, hyperglycemia, dyslipidemia, high blood pressure, smoking, thrombosis, kidney dysfunction and risk to specific populations (gender, older age, and race/ethnicity) [7].

A fact still unknown to many, CVD remains the leading cause of death amongst women, with premature menopause in particular being linked to an increased risk of coronary heart disease [8]. In the UK alone 7.6 million people live with heart and circulatory conditions and there are over 100,000 hospital admissions annually due to heart attacks and 450 deaths daily due to a heart or circulatory disease [9]. In England alone CVD-related healthcare costs are estimated to be around £7.4 billion annually, with annual costs to the wider economy being even higher-an estimated £15.8 billion [10]. It is also thought that acute CVD could be being overlooked because of the COVID-19 pandemic [11].

It is important to consider that the mind and heart are intricately linked. Depression, even at levels lower than those indicative of ‘clinical depression’ have been associated with increased risk of CVD [12]. Patients with major depressive disorder are known to have a higher prevalence of CVD, with neovascular health (development of new blood vessels especially in tissues where circulation has been impaired by disease or trauma) gaining increasing attention as one possible underlying mechanism [13]. Given the present set of circumstances, this publication aims to provide an updated review on the role of tea in relation to mind and heart health.

## Methods

The National Centre for Biotechnology Information (NCBI) search engine (PubMed.gov) was used to extract relevant publications.

English-language human studies published between 01<sup>st</sup> January 2000 and 07<sup>th</sup> September 2021 were screened. Publications were included if they used tea (*Camellia sinensis*) and studied specified health outcomes related to the mind and heart. The first search, which used the search term “Tea” combined with “Mind”, “Cognition”, “Brain health”, “Memory” and “Emotions”, was first undertaken. The second search applied the term “Tea” combined with “Heart health”, “Cardiovascular disease” or “Endothelial function”. Reference lists of key papers were also searched.

Both searches (for the mind and heart) were initially restricted to human studies and randomised controlled trials (RCTs). RCTs are regarded as the ‘gold standard’ for determining efficacy of research, reducing the risk of bias whilst examining cause and effect relationships between interventions and outcomes [14]. Exclusion criteria for both searches included: pilot studies, trials using tea ‘capsules’ or ‘supplements’, where outcomes did not relate directly to the mind or heart, or when a full text was unavailable. A separate second search was then undertaken using the same search terms and inclusion/exclusion criterion for ‘observational studies’ to encompass evidence from these.

## Results

### Randomised controlled trials

**Tea and the mind:** At least four RCTs have focused on tea ingestion in relation to outcomes related to the mind (Table 1). Yoto A, et al. and colleagues conducted two studies focusing on tea and salivary chromogranin-A (CgA) levels - a protein marker of stress [15,16]. Using a cross-over, single-blind, randomised design, two black tea aromas (Darjeeling and Assam) or hot water as the control were inhaled [16]. Inhaling black tea aromas (both forms) reduced salivary CgA concentration levels 30 minutes after mental stress load tasks [16]. Darjeeling tea aroma appeared to improve mood before mental stress load and reduced the anxiety and/or tension score immediately after the first exposure [16]. Yoto A, et al. (2014) [15] using a similar cross-over, single blind, randomised design, allocated 18 healthy adults to ingest either one 250 ml cup of sagara green tea, shaded white tea [shaded for so long it loses its colour as opposed to commercial ‘white tea’, which is produced *via* a process of solar withering followed

by indoor withering or water as a control [15]. Shaded white tea ingestion prevented increases in salivary CgA concentration levels after exposure to mental stress load tasks and also lowered total mood disturbance scores [15]. These findings implied that inhaling or ingesting certain tea forms could help to reduce markers of stress which in these instances were CgA [15,16].

Other work conducted by Steptoe and colleagues recruited 75 healthy non-smoking males, allocating these to drink the equivalent to four cups of strong black tea (or a caffeinated placebo) daily over 6-weeks [17]. In these population 6-weeks of black tea consumption resulted in greater subjective relaxation ratings and lower post-task cortisol levels when compared with the placebo [17]. The authors concluded that black tea ingestion could benefit health by facilitating stress recovery [17]. Other work by Hindmarch I, et al. (2000) found that drinking the equivalent to 1 to 2 cups of tea daily (containing 37.5 or 75 mg caffeine) induced similar alerting effects to coffee but was less likely to disrupt sleep [18].

**Tea and the heart:** A growing body of evidence (at least 13 RCTs) have studied inter-relationships between tea drinking and aspects of heart health (Table 2). The majority of RCTs (at least 11 studies) focused on black tea [19-29]. Two RCTs focused specifically on green tea ingestion [30,31].

Focusing on black tea studies, two focused on vascular function [19,20] and two studied heart rates [19,23]. Ahmad and colleagues recruited 17 healthy young adults (mean age 22.4 years) finding that black tea increased flow-mediated dilation compared with the hot water control [19]. The addition of milk, however, appeared to modulate the impact of black tea consumption on vascular function and increased SBP and DBP [19]. Amongst middle-aged adults (mean age 58 years) drinking 200 ml black tea improved cutaneous vascular responses, possibly *via* the activation of endothelium mediators such as nitric oxide [20]. In relation to heart rate, Ahmad AE, et al. (2018) reported that both black tea and black tea with milk reduced heart rate compared with the hot water control [19]. Hodgson JM, et al. (2013) also observed that heart rate was significantly lower for black tea providing 429 mg polyphenols during early-morning and night-time periods compared to the control [23].

**Table 1:** Tea and the Mind-Key RCT Publications.

Reference	Study Population	Study Design	Tea Intervention	Outcome of Interest	Main Findings
Yoto A, et al. (2018) [16] Japan	n=18 adults.	Cross-over, single-blind, randomised design.	Darjeeling, Assam, or hot water inhalation.	Salivary chromogranin-A levels-a stress marker	Darjeeling tea aroma appeared to improve mood before mental stress load. Inhaling black tea aroma could diminish stress levels triggered by arithmetic mental stress tasks.
Yoto A, et al. (2014) [15] Japan	n=18 students.	Three experimental trials on different days at intervals of 7 days.	1 cup (250 ml) of green tea (Sagara), shaded white tea or hot water.	Salivary chromogranin-A levels-a stress marker.	CgA level increased after the mental tasks. Green tea intake inhibited this increase. The anti-stress effect was even greater after shaded white tea consumption.
Steptoe A, et al. (2007) [17] UK	n=75 healthy non-smoking males.	4-week wash out and then 6-week trial.	4 cups of strong black tea (equivalent to) ingested daily.	Psychophysiological stress responsivity, post-stress recovery.	The active tea group had lower post-task cortisol levels compared with placebo (P=0.032), and a relative increase in subjective relaxation during the post-task recovery period (P=0.036).
Hindmarch I, et al. (2000) [18] UK	n=30 healthy adults.	5-way randomised crossover design.	1 or 2 cups of tea (containing 37.5 mg or 75 mg caffeine), coffee or water.	Alertness.	Day-long tea consumption produced similar alerting effects to coffee, despite lower caffeine levels, but was less likely to disrupt sleep.

**Key:** CgA: Chromogranin-A.

**Table 2:** Tea and the Heart-Key RCT Publications.

Reference	Study Population	Study Design	Tea Intervention	Outcome of Interest	Main Findings
Al-Shafei AIM, et al. (2019) [30], Egypt	n=100 adults 53 ± 4 years.	4-month randomised crossover study.	4x 250 ml green tea or hot water (placebo). Drank without sugar and milk.	Pulse pressure, left ventricular hypertrophy.	SBP, DBP, and PP were significantly lowered by 5.4%, 4.1%, and 7.7% from the baseline values after 4-weeks of green tea treatment.
Ahmad AF, et al. (2018) [19], Australia	n=17 adults, 22.4 years ± 3.0 years.	4-week controlled randomised crossover study.	Hot water, black tea, or black tea with milk	Vascular function.	Black tea increased FMD compared to the hot water control (P<0.0001). Black tea (P<0.001) and black tea with milk (P=0.001) lowered heart rate compared to hot water.
Woodward KA, et al. (2018) [20] UK	n=20 healthy males, 58 ± 5 years.	7-days apart in a randomised, controlled, double-blind, cross-over design.	1x cup black tea or placebo (200 ml)	Vascular function.	Acute tea ingestion enhanced cutaneous vascular responses in healthy, middle-aged participants, possibly <i>via</i> a mechanism related to activation of endothelium-derived chemical mediators, such as NO.
Grassi D, et al. (2016) [29] Italy	n=19 hypertensive patients.	8-day randomized, double-blind, controlled, cross-over study.	2x cups black tea beverage daily (150 mg polyphenols) or a placebo.	Endothelial progenitor cells, flow mediated dilatation.	Tea increased FMD 1, 2, 3, and 4 h after consumption, with maximal response 2 h after intake (P<0.0001).
Greyling A, et al. (2016) [21] Netherlands	n=20 healthy adults, 45-75 years.	2-hr after consumption-double-blind, randomised, placebo-controlled crossover intervention study.	2-3X cups black tea providing 400 mg flavonoids or colour/taste matched placebo.	Resistance artery endothelial function.	There was no evidence that acute intake of black tea significantly altered endothelium-dependent vasodilation of forearm resistance arteries.
Grassi D, et al. (2015) [28] Italy	n=19 hypertensive patients	8-day randomized, double-blind, controlled, cross-over study.	2x cups black tea beverage daily (150 mg polyphenols) or a placebo.	Blood pressure, wave reflections	Black tea significantly decreased SBP and DBP. Reflection index and stiffness index decreased after tea consumption (P<0.0001).
Schreuder THA, et al. (2014) [22] Netherlands	n=20 healthy subjects.	7-day x2 randomised, crossover study.	3x cups black tea black tea or tea abstinence.	Brachial artery flow-mediated dilation, ischaemia-reperfusion.	Tea consumption resulted in an immediate increase in FMD% (pre-consumption: 5.8; post-consumption: 7.2 P<0.01). No change occurred after hot water ingestion.
Hodgson JM, et al. (2013) [23] Australia	n=111 adults.	Randomised placebo-controlled double-blind parallel designed trial.	3x cups black tea over 1 day (powdered black tea solids containing 429 mg of polyphenols) or a control.	Blood pressure, heart rate.	Heart rate was significantly lower for tea compared to control during the night-time and early-morning periods (-2.0 (95% CI, -3.2, -0.8) bpm, and -1.9 (95% CI, -3.7, -0.2) bpm, respectively), but not during the daytime.
Grassi D, et al. (2009) [24] Italy	n=19 healthy males.	5 x1 week periods in a randomised, double-blind, controlled, cross-over design.	2x black tea intake - five treatments with a twice daily intake of black tea (0, 100, 200, 400 and 800 mg tea flavonoids/day).	Flow-mediated dilation.	100 mg/day (less than 1 cup of tea) increased FMD compared with control (P=0.0113).
Nagaya N, et al. (2004) [31] Japan	n=20 healthy smokers.	2 days, 1 week apart - randomised crossover study.	400 ml green tea or hot water.	Endothelial dysfunction.	Green tea consumption significantly increased FBF during reactive hyperaemia (P<0.001).
Hodgson JM, et al. (2002) [25]	n=21 subjects with mildly elevated serum cholesterol or triacylglycerol.	4-week trial.	5x cups black tea or hot water daily.	Brachial artery vasodilator function.	Regular ingestion of black tea resulted in a significant increase in endothelium-dependent dilatation (2.3%; P=0.008) and in a significant increase in endothelium-independent dilatation (4.2%; P=0.03), compared with ingestion of hot water.
Duffy SJ, et al. (2001) [26] USA	n=66 patients with coronary artery disease.	4-week randomised-controlled crossover study.	900 ml black tea or hot water daily.	Endothelial dysfunction.	Short-and long-term tea consumption increased endothelium-dependent flow-mediated dilation of the brachial artery, whereas consumption of water had no effect (P<0.001).
Hodgson JM, et al. (2001) [27] Australia	n=22 adults.	4-week randomised-controlled crossover study.	5x cups black tea or hot water daily.	Haemostasis, cell adhesion molecules.	Black tea resulted in lower soluble P-selectin (P=0.01) versus hot water but did not influence other adhesion molecules.

**Key:** BP: Blood Pressure; CI: Confidence Interval; DBP: Diastolic Blood Pressure; FBF: Forearm Blood Flow; FMD: Flow-Mediated Dilatation; NO: Nitric Oxide; P: Probability; PP: Pulse Pressure; SBP: Systolic Blood Pressure.

**Table 3:** Tea, the Mind and Heart-Key Observational Publications.

Reference	Study Population	Study Design	Outcome of Interest	Main Findings
<b>The Mind</b>				
Yao Y, et al. (2021) [39] China	n=13,115 adults.	Chinese Longitudinal Healthy Longevity Survey	Depression.	Compared with the group of no tea drinkers, ORs of depressive symptoms for daily green tea, fermented tea, and floral tea intake were 0.85 (95% CI: 0.76-0.95), 0.87 (95% CI: 0.76-0.99), and 0.70 (95% CI: 0.59-0.82) amongst older Chinese adults.
Okello EJ, et al. (2020) [40] UK	n=676, 85+ years.	Community based longitudinal study.	Attention, psychomotor speed.	High level of tea consumption was associated with significantly better attention (focused and sustained attention), and psychomotor speed (complex tasks only) over five-year follow-up.
Shirai Y, et al. (2020) [41] Japan	n=620 males, n=685 females, 60-85 years.	Prospective cohort study.	Cognitive decline.	Green tea lowered the risk of cognitive decline. Compared with participants who consumed green tea <once/d, the multivariable hazard ratio (95% CI) was 0.70, 0.71 and 0.72 among those who ingested green tea once/d, 2-3 times/d and ≥ 4 times/d, respectively.
Lee CY, et al. (2017) [32] Taiwan	n=10432 residents, n=2049 with mild cognitive impairment, n=929 with dementia, n=7035 without dementia or mild cognitive impairment.	Cross-sectional observational study.	Dementia.	Inverse associations between green tea and dementia (OR 0.51, 95% CI 0.34-0.75) and other types of tea consumption (OR 0.41, 95% CI 0.28-0.60) were found.
Bryan J, et al. (2012) [33] Australia	n=95 professional and academic staff.	Cross-sectional observational study.	Mood.	Ingestion of non-caffeinated beverages was associated with increased relaxation and recovery from work. Tea and other caffeinated beverages, however, were found to enhance the negative effects of evening recovery and morning mood on mindfulness during the day.
Shimbo M, et al. (2005) [34] Japan	n=600 aged 20-69 years.	Cross-sectional observational study.	Mental health.	The ingestion of brewed green tea was not statistically associated with any decrease in risk of mental ill-health among either males or females.
<b>The Heart</b>				
Chen Y, et al. (2019) [35] China	n=267 cases of CHD and 235 non-CHD controls were enrolled.	Hospital-based case-control study.	Coronary Heart Disease.	CHD risk was reduced in women who ingested 1-2 cups of tea per day (OR=0.291, 95% CI: 0.131-0.643, P=0.0023). A tea-drinking frequency of >6 days/week was beneficial for CHD prevention (OR=0.183, 95% CI: 0.049-0.679, P=0.0112).
Li X, et al. (2017) [36] China	n=199 293 men and 288 082 women aged 30-79 years at baseline.	Prospective study using the China Kadoorie Biobank.	Ischaemic heart disease.	Daily tea consumption was associated with a reduced risk of IHD compared with participants who never consumed tea during the past 12 months.
Liu DC, et al. (2016) [37] China	n= 80, n=401 atrial fibrillation patients and 400 controls.	Case-control study.	Atrial Fibrillation.	Green tea intake seemed to be a protective factor against the incidence of atrial fibrillation (OR: 0.349, 95% CI: 0.253-0.483, P<0.001).
Chrysohoou C, et al. (2016) [38] Greece	n=30 men and 343 women, aged 65 to 100 years.	Cross-sectional observational study.	Cardiovascular Disease.	Tea drinking was inversely associated with CVD incidence.

**Key:** CHD: Coronary Heart Disease; CI: Confidence Interval; IHD: Ischaemic Heart Disease; MCE: Major Coronary Events; OR: Odds Ratio.

Other RCTs investigated markers of endothelial function or flow-mediated dilation (FMD) [21,22,24-26]. Longer trials tended to report beneficial effects. For example, Grassi D, et al. (2009) conducted a 5-week trial on 19 healthy males, finding that less than one cup of black tea daily increased flow-mediated dilation (FMD) compared with the control [24]. A 4-week trial recruiting 21 adults with mildly elevated serum cholesterol/triacylglycerol at baseline, found that drinking 5 cups of black tea daily consistently and significantly improved endothelium dilatation indicating that black tea improved the vasodilator function which could be a plausible mechanism for lowering CVD risk [25]. Similarly, in another 4-week trial drinking 900 ml of black tea daily was linked to reversed endothelial vasomotor function in coronary artery disease patients [26]. In a shorter 8-day study Grassi D, et al. and colleagues (2015; 2016) found that black tea sachet ingestion (diluted with 100-200 ml hot water) improved levels of functionally active circulating angiogenic cells and FMD, particularly 2-hours after intake [29]. Systolic and diastolic blood pressure, blood pressure and wave reflections also improved [28]. Schreuder THA, et al. (2014) posits that drinking 3 cups of black tea daily significantly improved FMD [22].

Conversely, in a shorter-term trial monitoring vasodilation 2 hours after tea consumption (equivalent to 2-3 cups) there were no effects observed [21]. The authors concluded that longer periods of tea ingestion may be required to observe any effects [21]. One trial sought to evaluate the effect of black tea ingestion (5 cups daily) on cell adhesion molecules, concluding that black tea lowered P-selectin which could be another potential underpinning mechanism behind the cardiovascular benefits of tea ingestion [27].

Regarding green tea, Al-Shafei AIM, et al. (2019) recruited 100 adults allocating these to ingest four 250 ml cups of green tea per day (without milk or sugar) or hot water daily over 8-months [30]. At this level of intake, regular green tea consumption induced cardio protective effects - pulse pressure, systolic and diastolic blood pressure reduced significantly by 9.1%, 6.6% and 5.1%, respectively, midway through the study at 4-months [30]. A shorter and smaller trial conducted on two separate days provided healthy male smokers with 400 ml green tea or hot water [31]. Blood pressure and heart rate were unaffected but markers of endothelial dysfunction were reversed green tea consumption significantly improved forearm blood flow during a period of reactive hyperaemia (increased blood flow due to ischemia or arterial blockage) [31].

## Observational Evidence

Several observational studies appear to have focused on outcomes related to the mind [32-34] or heart [35-38]. Longitudinal research found that regular tea drinking (green, fermented, floral) amongst older Chinese adults was associated with fewer depressive symptoms [39]. Another large nationwide survey (n=10432) conducted across all 19 counties in Taiwan observed that green tea (OR 0.51, 95% CI 0.34-0.75) and other types of tea (OR 0.41, 95% CI 0.28-0.60) were inversely associated with dementia [32]. Similarly, in the United Kingdom, a longitudinal community study found that higher tea intakes were associated with significantly improved attention and psychomotor speed amongst those aged 85 years or older [40]. Other prospective cohorts [41] found green tea (up to 4 cups daily) to be associated with a reduced risk of cognitive decline in older populations aged 60 to 85 years.

Earlier research using a naturalistic, cross-sectional study design recruited professional and academic staff who logged their beverage intake and registered their work performance [33]. Multilevel modeling

analysis found that non-caffeinated drinks, particularly when served without milk or sugar, reduced tiredness and improved perceived work performance, but when caffeinated the beverage appeared to enhance negative effects of evening recovery or mindfulness [33]. Other observational evidence also suggests that caffeinated beverages could potentially impact on mental well being Shimbo M, et al. (2005) conducted a cross-sectional study consisting of 600 adults [34]. After several data adjustments for potential confounders, daily caffeine intake (100 mg) which included black tea, green tea, coffee, and other caffeine-containing beverages was associated with a higher odds of mental health problems amongst females [34].

As with the mind, several observational studies have studied inter-relationships between tea drinking and markers of heart health. In Guangzhou, China, tea ingestion (1-2 cups daily or black, oolong or green tea) was associated with reduced coronary heart disease risk amongst females, with a tea-drinking frequency of >6 days per week being regarded as beneficial for the prevention of coronary heart disease [35]. Other prospective research using data from the Chinese Kadoorie Biobank found that daily tea consumption (black, oolong or green tea) reduced ischaemic heart disease risk, particularly in rural, healthy weight, non-diabetic adults [36]. Liu DC, et al. (2016) again conducted research in a Chinese population and found that low-dose green tea ingestion, which accounted for the frequency, concentration, and duration of green tea intake, lowered a trial fibrillation incidence [37]. In the Greek Ikaria Island Study (a region with one of the highest global life expectancies), tea drinking was associated with a reduced risk of CVD [38].

## Potential mechanisms

**The mind:** There have been several theories proposed about how tea could affect the human mind. In particular, the tea components L-theanine and caffeine are understood to have synergistic effects, helping to reduce mind deviation to distractors, such as mind wandering, thus improving attention [42]. Multiple compounds in tea have been found to be effective modulators of dopaminergic activity and the gut-brain axis [43]. Tea constituents present in major tea forms, including L-theanine, polyphenols and polyphenol metabolites, for example, are capable of functioning *via* multiple pathways collectively helping to reduce depression risk [43].

Systematic analyses have previously concluded that green tea appears to reduce anxiety, improve attention and memory and aspects of brain function e.g., activation of working memory but such effects cannot be pinpointed to a 'single' tea constituent [44]. For green tea, its constituent catechins, including epigallocatechin gallate (EGCG), are proposed to be involved in mechanisms including preventing inflammation, oxidative stress and the abnormal accumulation of fibrous proteins (particularly A $\beta$  and  $\alpha$ -synuclein) which could contribute to neurodegenerative conditions such as cognitive dysfunction and memory loss [45]. Pioneering research using electroencephalogram technology measuring brain activity showed that 'theta waves' increased significantly 30 minutes to 1 hour after green tea consumption. Scientists proposed that this could be one way in which green tea exerts its potential effects on alertness, attention, and cognitive function [46]. More recently, green tea has been proposed to suppress brain ageing [47]. EGCG and theanine - the bioactive components unique to green tea - are thought to play a role in this by activating nerve cells and reducing stress [47].

**The heart:** A growing number of potential mechanisms protecting cardiomyocyte function including antioxidant, anti-inflammatory, anti-proliferative effects, reducing blood lipids, alleviating ischemia,

and favorable modifications to endothelial function have been linked to tea and its bioactive compounds and are reviewed elsewhere [48,49].

Tea polyphenols, (Table 3) in particular, are thought to be responsible for exerting some of these effects [50]. For example, it has been proposed that tea polyphenols can suppress certain inflammatory factors, including nuclear factor-kappa B (NF- B) [50]. Catechins, the predominant polyphenols in green tea have been linked to vascular effects *via* its ability to scavenge free radicals, inhibit enzymes involved in lipid biosynthesis, regulation of vascular tone by activating endothelial nitric oxide and prevention of vascular inflammation [51].

In laboratory models, black tea has been found to attenuate markers of vascular dysfunction, potentially by down-regulating homocysteine enzymes [52]. This is thought to be beneficial as elevated homocysteine levels are typically a marker of CVD risk and can induce endoplasmic reticulum stress in endothelial cells, exacerbating vascular dysfunction [52].

## Discussion

An established body of RCTs and growing body of evidence has focused on tea consumption in relation to the heart and mind, respectively. For the heart, the majority of RCTs (at least 11 trials) have focused on black tea ingestion, with study intakes ranging from 1 to 5 cups daily [20,25,27]. An array of outcomes have been investigated, ranging from vascular function, endothelial dysfunction, blood pressure, heart rate, FMD to levels of cell adhesion molecules. Most studies indicate that regular black tea ingestion could attenuate certain underpinning CVD risk factors including blood pressure, vascular and endothelial dysfunction [20,22,24-26,28,29]. Observational research, predominantly conducted in China is suggestive of positive links between tea drinking and aspects of heart health, particularly amongst females [35,36,38]. Elsewhere, meta-analytical evidence shows those longer durations of tea intake i.e.,  $\geq 3$  months, resulted in greater reductions in systolic and diastolic blood pressure [53]. These hypotensive effects were particularly pronounced for green tea compared with black tea in those with higher baseline blood pressure or hypertension [53]. Other meta-analytical work demonstrates that black or green tea ingestion could benefit adults with prehypertension or hypertension, thus potentially aiding secondary prevention of cardiovascular disease [54].

Regarding the mind, the number of RCTs is growing. Strong black tea consumption has been found to improve subjective relaxation ratings and lower post-task cortisol levels when compared with the placebo [17]. Other work showed that drinking the equivalent to 1 to 2 cups of tea daily (containing 37.5 or 75 mg caffeine) induced similar alerting effects to coffee but was less likely to disrupt sleep. In addition, observational evidence implies that tea drinking in general could improve attention and psychomotor speed [40], reduce depression [39] whilst green tea has been associated with reduced cognitive decline [41] and dementia [32] in advanced age.

Some observational studies also suggest that non-caffeinated tea drinking, without milk and sugar could aid relaxation and recovery from work [33]. The role of caffeine derived from beverages, however, remains emergent in relation to mental wellbeing and more research is needed. Higher levels of caffeine consumption have been associated with mental distress in populations of younger populations, especially males [55,56]. Ongoing research is needed but provisional findings appear to indicate that herbal tea infusions could be more suitable for aiding relaxation and reducing stress *via* their inhalation and ingestion [15-17,33,57]. On elimination with some observational studies is that different tea forms are often collated together making clear conclusions

a challenge. Future studies need to 'separate out' baseline populations, tea forms and better align study outcomes.

From a social stance, research from surveys has also shown that tea drinking could have extended social and wellbeing implications, with some of these outcomes not yet being studied formally in studies. For example, an Omnibus survey of 1000 UK adults reviewed by the tea advisory panel found that 57 percent of British tea drinkers said that the tea round at work helped them to feel connected to colleagues [58]. Forty-four percent reported that drinking black tea helped them to feel calm and 36 percent said it helped them to tackle a busy day. One-fifth (22%) of respondents working from home say that they miss the tea break at work and one-third (32%) admitted that there's a lot of truth to the saying "a cup of tea is the answer to every problem". These qualitative findings suggest that tea drinking has wider social ramifications that could impact on mindset. This would be worthy of future investigation.

## Conclusions

A reasonable conclusion from the available evidence is that including daily tea intake as part of a healthy habitual dietary pattern could be associated with lower cardiovascular disease risks [59]. The UK Eat well Guides presently advises us to drink 6-8 glasses of fluid every day and water, lower fat milk and sugar-free drinks including tea and coffee all count [60]. In essence, data is nebulous at present to specifically conclude whether tea consumption could improve mental well being. Provisional evidence implies that drinking (e.g. black, green, herbal infusions) and inhaling the aroma of certain teas (Darjeeling tea) could aid relaxation, lower markers of stress, dementia risk and cognitive decline and potentially improve attention and psychomotor speed in advanced age. Further trials are now warranted.

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## Conflicts of Interest

The authors declare no conflicts of interest. The views expressed are those of the authors alone and personnel from the United Kingdom Tea & Infusions Association (UKTIA) had no role in writing this review.

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