

Hibiscus Tea and Health: A Scoping Review of Scientific Evidence

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Abstract

Over the last few decades, health evidence has been building for hibiscus tea (*Hibiscus sabdariffa* L. Malvaceae). Previous reviews show promise in relation to reducing cardiovascular risk factors, hypertension and hyperlipidaemia, but broader health perspectives have not been widely considered. Therefore, a scoping review was undertaken to examine the overall health effects of hibiscus tea. A PubMed search was undertaken for meta-analysis (MA) and systematic review papers, human randomised controlled trials (RCT) and laboratory publications investigating inter-relationships between hibiscus tea and health. Twenty-two publications were identified (four systematic/MA papers, nine human RCT controlled trials and nine laboratory publications). Strongest evidence exists in relation to cardiovascular disease, suggesting that drinking 2-3 cups daily (each ≈ 240-250 mL) may improve blood pressure and potentially serve as a preventative or adjunctive therapy against such conditions. Emerging evidence exists for favourable effects on lipid profiles, insulin resistance, oxidative stress and inflammation. Further research using larger and longer human studies is warranted.

Keywords: Hibiscus tea; Health; Antioxidants; Polyphenolic compounds; Cardiovascular disease; Blood Pressure

Introduction

Hibiscus tea is usually derived from the dried calyces of the tropical plant *Hibiscus sabdariffa* L. (HSL) which belongs to the mallow family (Malvaceae) [1]. It is thought to be a native of West Africa, but is commonly cultivated across the tropics and subtropics including in China, Egypt, Mexico, Thailand and the West Indies [2]. HSL is sometimes referred to in English as 'roselle' or 'red sorrel' and in Arabic as 'karkade' [3]. This naming is attributed to its colouring with the roselle calyx being a bright red colour and abundant in anthocyanins [4]. It is the calyces (outer parts of the flower) that are most commonly used worldwide, to make hot and cold infusions [3]. HSL is also rich in organic acids and thus is also referred to as 'sour tea' due to these providing a distinctive tart taste [5].

Hibiscus tea is becoming increasingly popular which largely appears to be attributed to its bioactive properties, which could benefit public health [6,7]. From a historical perspective HSL has been used in folklore and traditional medicines [8,9]. Its rich phytonutrient profile may be responsible for such reported health effects [1]. For example, the phenolic acid protocatechuic acid, organic acids (hydroxycitric acid and hibiscus acid) and anthocyanins (delphinidin-3-sambubioside and cyanidin-3-sambubioside) have been listed as important bioactive components within HSL [10]. A compositional analysis of *Hibiscus calyces* found these to be rich in lutein, chlorogenic acids and delphinidin 3-sambubioside [11]. HSL extracts have additionally been found to have antioxidant and antimicrobial properties [7].

A growing body of evidence suggests that herbal teas, including HSL could benefit aspects of preventative and clinical health [8]. For example, one MA [5] of five RCT comprised of 390 participants found that HSL had significant effects lowering both systolic and diastolic blood pressure. HSL extracts have also been found to have anti-diabetic, anti-hypertensive, nephro- and hepato-protective effects as well as potential benefits on lipid metabolism and renal-diuretic effects [10]. These actions have been ascribed to HSL extracts having a notable antioxidant profile, vasorelaxant effects and ability to inhibit α -glucosidase, α -amylase, angiotensin-converting enzymes and modulate calcium channels [10]. Other work has reported that HSL could also have potential anti-obesity actions [12,13]. A systematic review of ten studies concluded that HSL may have a role in the treatment of mild to moderate hypertension, although ongoing research is warranted [14].

Taking the growing evidence-base on board, the present scoping review aims to collate evidence from systematic reviews, MA papers, human trials and laboratory studies, investigating inter-relationships between hibiscus tea consumption and health.

Methods and Materials

Study design

Scoping reviews are useful for collating evidence on a topic-they are a form of knowledge synthesis and useful for answering broader questions, including what is known about a concept [15].

For the screening of human trials the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was used (Figure 1) [16]. Alongside this, the recently published PRISMA Extension for Scoping Reviews (ScR) checklist developed by a 26-member expert panel was also applied. [16] The quality of human trials was further determined using the validated Jadad criterion [17].

Inclusion/Exclusion criteria

The present scoping review analysed associations between hibiscus tea and markers of health. Included papers were published in English-language in peer-reviewed journals. Human trials were screened and used hibiscus delivered as teas, infusions or aqueous extracts (specifying the amount consumed) rather than concentrated extracts or supplements. Trials were limited to RCTs using the PubMed search restriction tab. RCTs are regarded as the 'gold-standard' for identifying causal relationships as they largely eliminate bias typically associated with other study designs [18].

Multi-interventions using combinations of tea infusions, medications, tea supplements, condensed extracts or other interventions that could potentially confound results were excluded when screening human studies. Interventions, however, where different tea forms were randomly allocated to separate groups of participants were included. No time restrictions were applied for the systematic, MA review or RCT search. A restriction of ten years was applied to the laboratory studies.

Search strategy & data charting

The search for relevant studies was conducted using the PubMed database. For the identification of publications, the search terms "Hibiscus tea" or "*Hibiscus sabdariffa* tea" or "roselle tea" or "sour tea" were used and acknowledged as text words [tw] within the PubMed search strategy. Further to this, a manual search for publications was undertaken by screening the references listed in key studies. The search focused on gathering evidence from: (1) Prior systematic review and MA papers, (2) Human trials and (3) Laboratory publications (studies and reviews). Search restrictions were customised and limited to: Systematic reviews, MA papers, human RCTs and laboratory publications.

Studies were screened using the listed inclusion/exclusion criteria and identified by the two contributing authors. Studies were initially screened using their title. They were then further verified using the abstract. The procedure of identification, screening, evaluation of eligibility and inclusion is illustrated in Figure 1.

Data charted from the human trials included the following: General details of the study, participants, study design, tea intervention (type and dosage), health outcome(s) and main study findings with any reported significant p-values. For laboratory publications data relating to the study and its design (laboratory model) were extrapolated, Hibiscus intervention/focus and health outcomes were extracted along with the main findings.

Results

The search for articles identified 31 publications initially (seven MA papers, eight RCTs from PubMed, three RCTs from literature sources and 13 laboratory papers). Of these, three systematic/MA papers and four laboratory publications were irrelevant and two trials used supplements or medications. Subsequently 22 papers were eligible for inclusion within the review-four systematic/MA papers, nine human RCTs and nine laboratory studies (Figure 1).

Most of the articles focused on aspects of cardiovascular wellbeing (Table 1). Three concentrated on hypertension or blood pressure [5,19,20] and two serum lipid levels [21,22]. Two MA studies found that both sour tea and HSL significantly reduced systolic and diastolic blood pressure [5,19]. Significant reductions in plasma glucose levels were also observed in an analysis conducted by Najafpour Boushehri S, et al. (2020) [19]. In earlier reviews, findings were less conclusive. Aziz Z, et al. (2013) [21] collated evidence from six RCTs involving 474 participants and found no associations between HSL ingestion and total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol nor triglyceride levels. Hajifaraji M, et al. (2018) [22] observed significant reductions in mean total cholesterol, high density lipoprotein cholesterol and low density lipoprotein cholesterol levels compared to baseline values after participants with genetic (polygenic) dyslipidaemia ingested two cups of sour tea daily. Wahabi HA, et al. (2010) [20] collated data from four trials comprised of 390 patients finding that HSL did not appear to be an effective treatment for primary hypertension, although these trials were regarded to be poor quality.

Regarding human RCTs five focused on blood pressure or hypertension (Table 2) [23-27]. Four reported on lipid levels and profiles [23,28-30]. Some RCTs investigated other health outcomes including oxidative stress, [28] insulin resistance, [23,28] and inflammation [23]. Abubakar SM, et al. (2019) [23] researched vascular function and a cardiovascular disease (CVD) risk calculation was undertaken. All the RCTs observed notable improvements in health outcomes, which included improved postprandial vascular function [23], triglyceride levels [29-30], high-density lipoprotein cholesterol levels [28,30], insulin resistance [23,28] and blood pressure profile [24-27].

Of the interventions delivered infusions were generally given one to three times daily. Abubakar SM, et al. (2019) [23] steeped 30g (an average of 15 hibiscus tea bags) of *Hibiscus sabdariffa* calyces in 1 litre of low nitrate water for 10 min. Each volunteer was then served an equivalent extract of 7.5 g *Hibiscus sabdariffa* calyces (about 3-4 hibiscus tea bags) in 250 mL Buxton water once daily. In four other studies 240 mL servings were delivered two or three times daily with this appearing to benefit systolic and diastolic blood pressure and triglyceride levels [25,26,29,30]. Some studies administered the tea interventions with a date or sugar cube to aid compliance in case the tea flavour was disliked [26,28].

As shown in Table 3 seven studies scored 3 or more after applying the Jadad criteria indicating that they were of moderate to high quality. One study [29] did not mention randomisation methods nor specify whether blinding was undertaken so was graded as lower quality (a score of 2). The three studies that were 'moderate quality' received lower scores because blinding methods were not clearly specified [24,27,28].

Nine laboratory publications were identified; the majority which were murine models (Table 4). Various HSL interventions were used. Five papers reported that they used aqueous extracts, infusions or drinks [31-35]. Earlier work by Hopkins AL, et al. (2013) [36] purported that HSL reduced cholesterol, low-density lipoprotein cholesterol and triglycerides in most diabetic, hyperlipidaemic and normolipidemic laboratory models. Similarly, Lin HH, et al. (2011) [37] evaluated laboratory models using various HSL forms finding that these appeared to benefit atherosclerosis, cancer, diabetes, liver disease and metabolic syndromes.

Two laboratory models [31,33] one fed a high fat diet observed improvements in cardiac function, which was most likely mediated

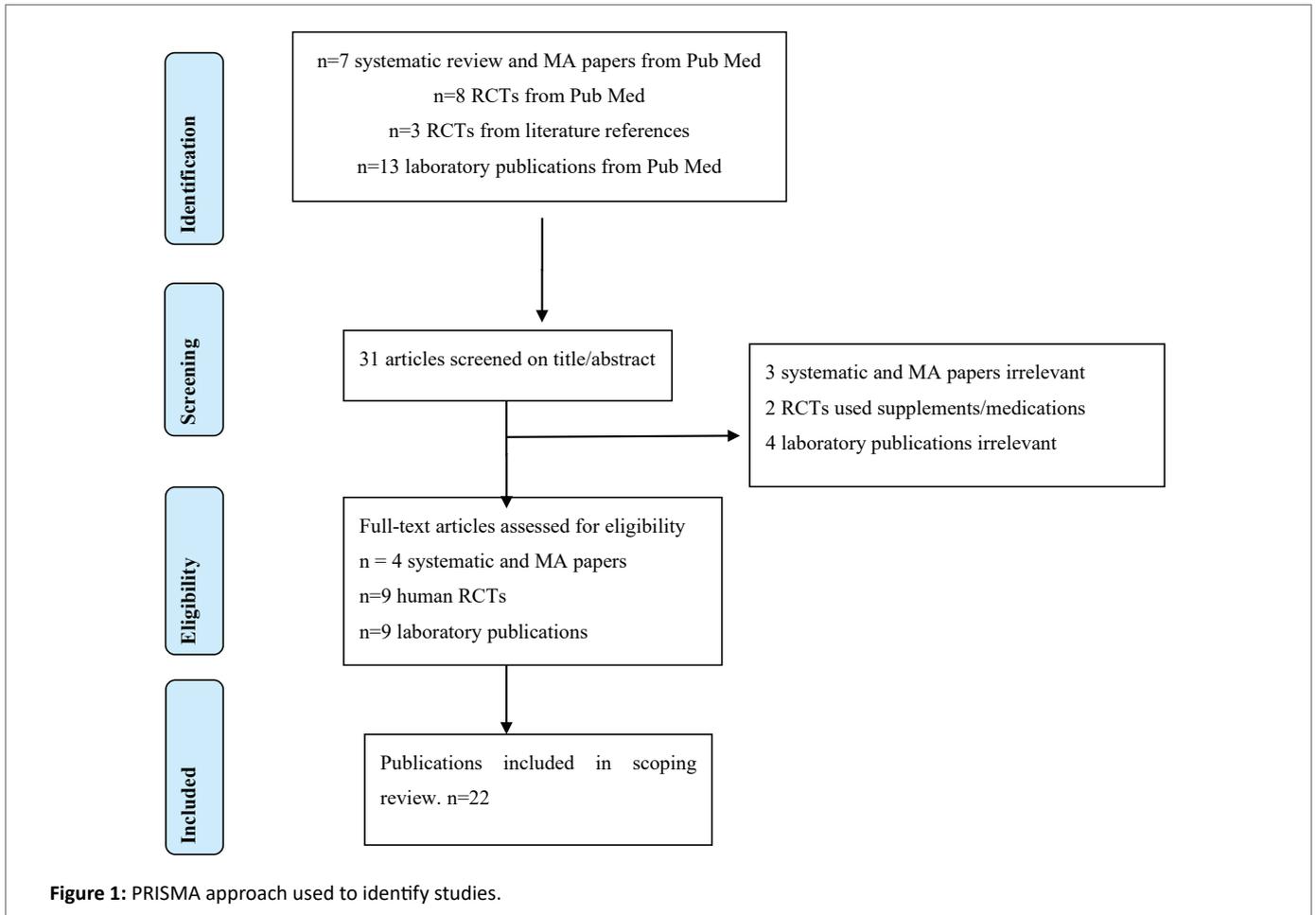


Table 1: Hibiscus tea and health: Evidence from systematic reviews and meta-analysis papers.

Author	Health Outcome	Main Finding(s)
Najafpour Boushehri S, et al. (2020) [19]	Glycaemic status, blood pressure	MA of 7 RCTs showed sour tea consumption significantly reduced fasting plasma glucose, SBP and DBP.
Serban C, et al. (2015) [5]	Arterial hypertension	MA of 5 RCTs showed a significant effect of HSL in lowering both SBP and DBP.
Aziz Z, et al. (2013) [21]	Serum lipids	Available evidence from 6 RCTs does not support the efficacy of HSL in lowering serum lipids.
Wahabi HA, et al. (2010) [20]	Hypertension	The 4 RCTs identified do not provide reliable evidence to support recommending HSL for the treatment of primary hypertension in adults.

*DBP- Diastolic Blood Pressure; HSL- *Hibiscus sabdariffa L.*; RCTs- Randomised Controlled Trials; SBP- Systolic Blood Pressure

through antioxidant activities. Lee YS, et al. (2018) [38] used a synergistic intervention which included hibiscus flower extracts and found that these reduced obesity in mice fed a high-fat diet. Some work showed that HSL calyces or a roselle drink reduced hepatic and renal inflammation, respectively, possibly by down regulating biochemical components of inflammatory pathways [34,39]. One study [32] reported renal benefits amongst rodents with induced chronic kidney disease effects that were ameliorated in a dose-dependent manner. Surprisingly one study by Mahmoud YI (2012) [35] observed that aqueous extracts from dried HS calyx inversely influenced male murine reproductive fertility but these effects have not since been replicated.

Beyond the span of this scoping review HSL extract has also been found to alter parameters associated with the development of obesity, including cholesterol metabolism, lipid accumulation, adipocyte differentiation and adipogenesis and its inhibitory effects on pancreatic lipase [13]. Some research [40,41] using a combination of HSL polyphenolic extracts and *Lippia citrodora* Paláu (syn *Aloysia citrodora*) Verbenaceae observed improved, blood pressure and heart rate parameters amongst obese adults with observed increases in anorexigenic and reductions in orexigenic hormones. Moreover, a multicentric pilot clinical study [42] of 38 adults with blood pressure above 140/90 mmHg showed that HSL (10-20 g of HSL per 0.5 litres of tea daily) was helpful in treating uncontrolled hypertension and

Table 2: Hibiscus tea & health: Evidence from human trials.

Study (Author, Year, Location, Reference Number)	Subjects (age, gender)	Study design	Tea Intervention (type)	Tea Intervention (dosage)	Health Outcome(s)	Main Findings (with any reported significant p-values)
Abubakar SM, et al. (2019) [23] UK	n=25 with 1% to 10% CVD risk	SB RCT	Aqueous extract of HSC or water	250 ml	Postprandial Blood Pressure, Vascular Function, Blood Lipids, Biomarkers of Insulin Resistance and Inflammation	HSC extract improved postprandial vascular function and could be a useful dietary strategy to reduce endothelial dysfunction and CVD risk.
Hajifaraji M, et al. (2018) [22] Iran	n=43 adults (30-60 years old)	12-week RCT	Dorsa sour tea	Two cups of sour tea daily	Dyslipidaemia	Mean concentration of total cholesterol, HDL-C and LDL-C significantly decreased in the intervention group in comparison to their baseline values.
Jeenduang M, et al. (2017) [29] Thailand	Subjects with hypercholesterolemia n=48	30-day trial	<i>Hibiscus sabdariffa</i> or <i>Gynostemma pentaphyllum</i> Makino tea	The tea sachet (3 g) was added to 240 mL of boiling water and drunk twice daily.	Lipid Levels	HS consumption may have beneficial effects with respect to TG concentrations in B2 carriers, but it may adversely affect HDL-C concentrations in homozygous B1B1 and E4 carriers.
Mozaffari-Khosravi H, et al. (2014) [28] Iran	Patients with T2D n=100	4-week RCT	Sour or green tea	150 mL infusion three times a day	Lipid Profile, Oxidative Stress, Insulin Resistance	Sour tea had positive effect on insulin resistance and increased HDL-C.
Mozaffari-Khosravi H, et al. (2013) [24] Iran	Mildly hypertensive patients with diabetes n=100	4-week RCT	Sour or green tea	Three glasses a day 2 hr after each meal.	Blood Pressure	Drinking three glasses of sour tea daily for 4 weeks significantly decreased SBP and DBP.
McKay DL, et al. (2010) [25] USA	Pre- and mildly hypertensive adults, n=65	6-week DB RCT	Brewed hibiscus tea or placebo beverage	Three 240 mL servings daily (720 mL/d)	Blood Pressure	Hibiscus tea lowered SBP compared with placebo. DBP was also lower, although this change did not differ from placebo.
Mozaffari-Khosravi H, et al. (2009a) [30] Iran (lipids)	Patients with diabetes n=60	1-month RCT	Sour or black tea	240 mL twice daily.	Lipid Profile and Lipoproteins	In the ST group, HDL-C increased significantly and total cholesterol, LDL-C, TGs and Apo-B100 decreased.
Mozaffari-Khosravi H, et al. (2009b) [26] Iran (hypertension)	Patients with diabetes and mild hypertension n=60	1-month RCT	Sour or black tea	240 mL twice daily.	Hypertension	The ST infusion had positive effects on systolic BP in type II diabetic patients with mild hypertension.
Haji Faraji M, et al. (1999) [27] Iran	Patients with moderate essential hypertension n=54	15-day RCT	Sour tea or control	Instructed to use one glass of the decoction (two spoonfuls of blended tea in one glass of boiled water boiled for 20–30 min).	Hypertension	There was an 11.2% lowering of SBP and a 10.7% decrease of DBP in the experimental group 12 days after beginning treatment.

*BP- Blood Pressure; CVD- Cardiovascular disease; DB- Double-blind; DBP- Diastolic Blood Pressure; HDL-C- High-Density Lipoprotein Cholesterol; HSL- *Hibiscus sabdariffa* Linne; HSC- *Hibiscus sabdariffa calyces*; LDL-C- Low-Density Lipoprotein Cholesterol; RCT- Randomised Controlled Trial; SB- Single-blind; SBP- Systolic Blood Pressure; ST- sour tea; STE- Sour Tea Extract; TG- Triglyceride.

Table 3: Jadad criterion used to assess quality of RCTs.

Publication	Randomisation	Method of Randomisation Described & Appropriate	Blinding Mentioned	Method of Blinding Described and Appropriate	Withdrawal and Dropout of Subjects Provided	Total Score
Abubakar SM, et al. (2019) [23] UK	1	1	1	0	1	4
Jeenduang N, et al. (2017) [29] Thailand	1	0	0	0	1	2
Mozaffari-Khosravi H, et al. (2014) [28] Iran	1	1	0	0	1	3
Mozaffari-Khosravi H, et al. (2013) [26] Iran	1	1	0	0	1	3
McKay DL, et al. (2010) [25] USA	1	1	1	1	1	5
Mozaffari-Khosravi H, et al. (2009a) [30] Iran (lipids)	1	1	1	1	1	5
Mozaffari-Khosravi H, et al. (2009b) [26] Iran (hypertension)	1	1	1	1	1	5
Haji Faraji M, et al. (1999) [27] Iran	1	1	0	0	1	3

Total quality assessment score for which scores range between 1 and 5: with 1 being the lowest quality and 5 being the highest quality. 3=above average quality.

Table 4: Hibiscus Tea and Health: Evidence from Laboratory Publications.

Study (Author, Year, Reference Number)	Study Design	Hibiscus Intervention (type)	Health Outcome(s)	Main Findings
Pérez-Torres I, et al. (2019) [31]	Rat model	HSL infusion	Cardiac function	Treatment with an infusion from HSL calyces protected cardiac function from damage by ischemia and reperfusion through antioxidant activities.
Lee YS, et al. (2018) [38]	Obese mouse model	Combination of lemon verbena and hibiscus-flower extracts	Obesity	The formula decreased obesity and its complications in mice fed a high-fat diet.
Ali BH, et al. (2017) [32]	Rat model	Aqueous extract of HSL calyces (5 and 10%)	CKD	Adverse effects of CKD were significantly lessened in a dose-dependent manner.
Si LY, et al. (2017) [33]	Rat model-fed a high fat diet	Roselle aqueous extract	Cardiac function	Roselle had a protective effect on cardiac dysfunction in OB and OB+MI rats.
Chou ST, et al. (2016) [34]	Mouse model	Roselle drink	Inflammation (renal)	The roselle drink reduced LPS-induced renal inflammation by down regulating the cytokine network, pro-inflammatory product production, and NF-κB pathways.
Ezzat SM, et al. (2016) [39]	Rat model with induced hepatotoxicity	HSL calyces	Inflammation (hepatic)	The intervention decreased hepatic inflammatory markers, including tumour necrosis factor alpha, interleukin-6 and interferon gamma by 85.4, 14.9 and 70.9%, respectively.
Hopkins AL, et al. (2013) [36]	Review of laboratory studies	HSL	Lipid profile	Total cholesterol, LDL-C and TGs Reduced in most normolipidaemic, hyperlipidaemic, and diabetic laboratory models, whereas HDL-C was not affected by the consumption of HSL extract.
Mahmoud YI, et al. (2012) [35]	Mouse model - male albino mice	Cold or boiled Hibiscus aqueous extract or water.	Reproductive function	Aqueous extracts from dried calyx of HS, either cold or boiled appeared to adversely influence male reproductive fertility in albino mice.
Lin HH, et al. (2011) [37]	Evaluation of laboratory models (rodents and rabbits)	Various HSL extracts.	Atherosclerosis, liver disease, cancer, diabetes, metabolic syndromes.	Various HSL extracts exhibit activities against atherosclerosis, liver disease, cancer, diabetes and other metabolic syndromes.

*CKD- Chronic Kidney Disease; HDL-C- High-Density Lipoprotein Cholesterol; HPAIVs- Highly Pathogenic Avian Influenza Viruses; HSL- *Hibiscus sabdariffa* L.; LPAIVs- Low Pathogenic AIVs; LDL-C- Low-Density Lipoprotein Cholesterol; LPS- Lipopolysaccharide; MI- Myocardial infarction; NF-κB- Nuclear Factor-κB; OB- Obese; TGs- Triglyceride.

well tolerated. Work conducted with soccer players also demonstrated that 450 mg/d sour tea extracts after 6-weeks had beneficial effects on oxidative stress [43].

Discussion

The scoping review of scientific evidence found the strongest evidence-base for HSL and cardiovascular wellbeing. Three synthetic reviews, which included MA research, reported benefits for blood pressure and hypertension [5,19,20]. Five underpinning human RCTs also consistently observed improvements in blood pressure, particularly systolic blood pressure [23,25-28]. Evidence for serum lipids was less certain. For example, Hajifaraji M, et al. (2018) [22] concluded that sour tea could impact beneficially and significantly on subjects with polygenic dyslipidaemia, which could partly be attributed to its anthocyanin content and the genetic status of subjects. In contrast, earlier work undertaken by Aziz Z, et al. (2013) [21] found that evidence from the six RCTs analysed could not identify definite links between HSL and reduced serum lipids. Authors, however, reported that studies had small sample sizes and were underpowered which could have been attributed to the lack of findings.

It should also be considered that most studies recruited participants with CVD risk factors, hypercholesterolemia, hypertension or type 2 diabetes at baseline, thus were not healthy. This indicates that hibiscus tea consumption could be a useful adjunctive therapy from a protective health stance, particularly amongst individuals at risk of cardiovascular disease. Most human studies provided two-three servings of sour or brewed hibiscus tea daily with a serving typically being 240-250 mL [24-26,28-30]. Thus it would be reasonable to suggest that hibiscus tea drinking could be adopted as a dietary strategy to enhance individuals with elevated blood pressure or CVD risk. It has previously been reported that HSL extracts have a low degree toxicity and excellent safety tolerability [10,36] although some caution may be required if planning to conceive or pregnant [35,44].

In terms of potential mechanisms, it is well documented that the polyphenol profile of hibiscus tea could play a role in its health benefits and potential modern therapeutic uses [1]. Regarding cardiovascular benefits it has been postulated that the antioxidant effects of HSL induced by its anthocyanin profile could inhibit low-density lipoprotein oxidation, subsequently impeding atherosclerosis [36]. Other theories include that anthocyanins reduce low-density lipoprotein oxidation and inhibit adipogenesis *via* the regulation of transcription factors and adipogenic signalling pathways, which modulate the gene expression of certain microRNAs [45]. Recent work with type 1 diabetic rats has further shown that HSL renews pancreatic β -cells [46]. Laboratory publications suggest potential cardiac [31,35] and anti-inflammatory actions [34,39]. There was emerging evidence from human trials that hibiscus tea could have beneficial effects on insulin resistance [23,28] and levels of oxidative stress [28]. Ongoing human RCTs are now needed to focus on these aspects as primary research outcomes.

Other work has focused on how HSL could affect parameters of nutritional status. Research conducted on patients with vitamin B₁₂ deficiency and neurological symptoms who were given a combination of hydroxocobalamin and HSL found that vitamins injections were no longer required to replete B₁₂ status [47]. Extended research by this team of scientists using laboratory models confirmed that the bioavailability of intestinal hydroxocobalamin increased when synergistically used with HSL [47]. Ongoing work is now needed to replicate findings and further determine whether hibiscus tea could improve the bioavailability of nutrients, such as vitamin B₁₂-findings that could potentially be of benefit to vegetarian or vegan populations.

Elsewhere it has been observed that the iron and organic acid profile of HSL could potentially improve hematopoietic (iron status) parameters but larger human studies are needed [48,49].

With respect to limitations it should be considered that studies varied in terms of duration, forms of interventions and comparators used. Future studies should continue to use interventions that ultimately translate into public health guidance. Undoubtedly, more well-designed RCTs are needed using 'phytochemically characterised' preparations, which would aid comparative analyses between studies [10,50]. It must be indicated that future trials should better include and describe blinding methods to improve their quality. Clear randomisation approaches should also be adopted and outlined in publications. Certain populations such as pregnant mothers and those with kidney problems may be cautious to avoid excessive consumption of hibiscus infusions due to these being a source of aluminium which could accumulate in the body [51]. More research is also needed to better understand the toxicology of hibiscus as the ingestion of condensed HSL extracts would be somewhat different to that of infusions-excessive doses of HSL calyx doses, for example, over long durations have been found to have deleterious effects on testes of rats [3].

Conclusions

The present scoping review shows that hibiscus tea ingestion could benefit cardiovascular wellbeing. Emerging research also reveals potential benefits in terms of its ability to favourably modulate lipid profiles, inflammation, oxidative stress and insulin resistance. From a habitual perspective hibiscus tea could be consumed for its favourable phytonutrient profile and potential cardiovascular benefits. More extensive research is now warranted in the form of larger and longer human trials with clearly defined interventions.

Disclosure

The views expressed are those of the authors alone and personnel from the UK TEA & INFUSIONS ASSOCIATION (UKTIA) had no role in writing this review.

Conflicts of Interest

The authors declare no conflicts of interest.

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