beverages

Review

The Effect of Rooibos Tea (*Aspalathus linearis*) Consumption on Human Health Outcomes: A Systematic Literature Review

Kathryn E. Speer [1,2,3], Jeanine L. Marnewick [4], Simeon E. H. Davies [5], Murray Turner [1], Viktoriya L. Nikolova [6], Richard Day [6], Andrew J. McKune [1,2,3,7] and Nenad Naumovski [1,2,3,8,*]

1 Faculty of Health, University of Canberra, 11 Kirinari Street, Bruce, ACT 2617, Australia; katie.speer@canberra.edu.au (K.E.S.); murray.turner@canberra.edu.au (M.T.); andrew.mckune@canberra.edu.au (A.J.M.)
2 Functional Foods and Nutrition Research (FFNR) Laboratory, University of Canberra, Bruce, ACT 2617, Australia
3 Research Institute for Sport and Exercise (UCRISE), University of Canberra, Canberra, ACT 2601, Australia
4 Applied Microbial and Health Biotechnology Institute (AMHBI), Cape Peninsula University of Technology, Cape Town 7540, South Africa; marnewickj@cput.ac.za
5 Centre for Sport Business and Technology Research (CSBTR), Cape Peninsula University of Technology, Newlands Cricket Ground, Campground Rd, Cape Town 7700, South Africa; daviess@cput.ac.za
6 Department of Medical Affairs & Clinical Development, ADM Health & Wellness, London EC3R 7AG, UK
7 Discipline of Biokinetics, Exercise and Leisure Sciences, School of Health Sciences, University of KwaZulu-Natal, Durban 4000, South Africa
8 Department of Nutrition and Dietetics, School of Health Science and Education, Harokopio University, 17671 Athens, Greece
* Correspondence: nenad.naumovski@canberra.edu.au; Tel.: +61-(0)2-6206-8719

Abstract: Rooibos tea, traditionally consumed by Indigenous populations, is naturally caffeine-free and contains unique polyphenols with strong antioxidant, anti-inflammatory and anti-hyperglycaemic properties. As such, a systematic review was conducted following PRISMA 2020 guidelines (PROSPERO ID: CRD42023467829) to evaluate the potential association between rooibos tea consumption and health outcomes. Relevant articles were searched from journal inception until October 2024 using five electronic databases (CINAHL, MEDLINE, Scopus, Web of Science Core Collection and Google Scholar) and one register (Cochrane Clinical Register of Controlled Trials). Included studies involved consumption of any rooibos tea beverage or supplement in humans 18 years or older and reported any health outcomes measured pre- and post-intervention. Following article screening and full text review, eight studies (175 participants) fulfilled the inclusion criteria and investigated the effects of rooibos consumption on biological [blood (n = 6); urine (n = 1)] and physiological [heart metrics (n = 2); muscle strength (n = 1)] health markers. Based on the included studies, the findings suggest benefits of rooibos consumption, particularly related to cardiometabolic health, with five studies supporting significant ($p < 0.05$) results. However, there is insufficient evidence to support the health benefits of rooibos consumption given the limited studies meeting inclusion criteria, the narrow scope of markers assessed and interstudy heterogeneity.

Keywords: *Aspalathus linearis*; cardiometabolic; fermented; human health; rooibos; tea; unfermented

Citation: Speer, K.E.; Marnewick, J.L.; Davies, S.E.H.; Turner, M.; Nikolova, V.L.; Day, R.; McKune, A.J.; Naumovski, N. The Effect of Rooibos Tea (*Aspalathus linearis*) Consumption on Human Health Outcomes: A Systematic Literature Review. *Beverages* **2024**, *10*, 113. https://doi.org/10.3390/beverages10040113

Academic Editor: Antonio Cilla

Received: 18 October 2024
Revised: 10 November 2024
Accepted: 19 November 2024
Published: 22 November 2024

1. Introduction

Teas are the most frequently consumed beverages worldwide, after water [1]. With more than two billion cups brewed each day, tea consumption averages a per capita intake of 120 mL/day [1,2]. Tea is generally prepared after cultivating fresh tea leaves, processing them in some form (to obtain different varieties) and steeping the dried tea leaves in boiling water [3,4]. Tea has been consumed for centuries in countries such as China and Japan, often to aid in the management and treatment of disease [5,6]. Recently, there has been growing global interest in the use of teas as sources of phytochemicals and nutraceuticals

for reduction of disease risks, such as cardiovascular disease, cancer, neurogenerative disorders and stroke [1,4,7–9]. Habitual consumption of tea has also been shown to reduce blood pressure, serum lipid levels and fasting blood glucose levels, exert cardioprotective effects and facilitate weight loss [6].

Many of the most frequently consumed teas, such as green, black and oolong (all belonging to the evergreen shrub plant family, Theaceae), exert health-promoting and/or disease-reducing effects and also contain caffeine and high levels of tannins, which may induce negative side effects [10]. However, rooibos (*Aspalathus linearis*) herbal tea (Fabaceae plant family), brewed from the leaves of a shrubby legume plant endemic to South Africa, is caffeine-free and has a lower tannin content (producing a milder, more palatable tea) than other comparative teas [11,12]. Moreover, rooibos contains several unique polyphenolic compounds (aspalathin, nothofagin), flavones, flavanones and flavanols that are associated with strong antioxidant, anti-inflammatory and insulin resistance-reducing properties [13]. Rooibos is available in a red and green variety based on the processing of raw plant material. Red rooibos is produced by fermentation of the plant leaves and stems, which may reduce the levels of phenolic compounds. Whereas green rooibos is unfermented and therefore less exposed to oxidation, resulting in higher polyphenolic content and antioxidant properties than fermented rooibos [14,15].

Several studies have indicated that rooibos and its extracts exert antioxidative, anti-inflammatory, anti-hyperglycaemic, antimutagenic and organo-protective features [15,16]. From a mental health perspective, animal studies have demonstrated that rooibos extract may have anxiolytic potential [17]. However, these results are yet to be translated to humans. Research has shown potential health-promoting associations of rooibos and improved cardiovascular, metabolic, dermatological and antihistaminic outcomes [15,18–20]. Indeed, some of these studies have been performed in vitro and on animals, which limits conclusions of causality [20–22]. Whilst some human studies support the direct link between rooibos consumption and improved overall health, others do not [23–26]. Due to the possible health-promoting properties of rooibos tea reported in preclinical studies and previous evidence in human studies suggesting possible links between rooibos consumption and improved health outcomes, it is important to consolidate the evidence to date to provide more clarity on the potential of rooibos herbal tea as a nutraceutical. To the best of our knowledge, there is no systematic literature review examining rooibos consumption on aspects of human health. As such, the aim of this review is to explore the potential association between rooibos tea consumption and health outcomes in humans.

2. Materials and Methods

This systematic literature review has been reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 checklist [27] and was completed according to a protocol registered on the registry of systematic literature reviews (CRD42023467829).

2.1. Search Strategy

Five electronic databases, CINAHL, Google Scholar, Medline, Scopus, Web of Science Core Collection and one registry—Cochrane Central Register of Controlled Trials—were searched for all relevant articles published in English from journal inception until October 2024. The search applied Boolean operators (AND, OR) to make the search more specific.

2.2. Search Terminology

The terms implemented for this review included: "rooibos" OR "Aspalathus linearis" OR "aspalathi*" OR "nothofagin" OR "phenylpropenoic acid glucoside" OR "PPAG" OR "orientin" OR "isoorientin" OR "quercetin-3-O-robinobioside" AND "health*" OR "diet*" OR "cardiovascular" OR "CVD" OR "body mass index" OR "BMI" OR "cardiometabolic" OR "metabolic syndrome" OR "bodyweight" OR "waist circumference" OR "sleep" OR "NAFLD" OR "anxiety" OR "mental health" OR "depression*" OR "cogni*" OR "cancer*"

OR "gut" OR "microbiome*" OR "digestion" OR "diabetes*" OR "hypertension" OR "stress" OR "wellbeing" OR "psych*" OR "heart" (Table S1). A snowball search on the reference lists of relevant articles was also implemented to identify any additional articles potentially eligible for inclusion to ensure all relevant articles had been captured by the search strategy.

2.3. Eligibility and Data Extraction

Following the database searches, Covidence© systematic review software (Veritas Health Innovation, Melbourne, VIC, Australia) was used for the de-duplication of search results and for screening the retrieved articles. Two authors (K.E.S. and A.J.M.) independently reviewed the titles and abstracts of the relevant articles for inclusion against the selection criteria. Upon disagreement, the inclusion of each article was decided by a third author (N.N.).

Studies were eligible for inclusion if they possessed the following criteria: (1) used a randomised or non-randomised controlled (crossover or parallel) trial design; (2) conducted in humans (18 years or older); (3) involved the consumption of any rooibos tea extract supplement or rooibos tea beverage; (4) reported any biochemical, physiological, anthropometric and/or psychological outcomes measured before and after the intervention.

Following the initial screening process, the full texts of remaining articles were then screened and reasons for excluding articles were recorded. A detailed screening process for article selection is illustrated in the PRISMA diagram (Figure 1).

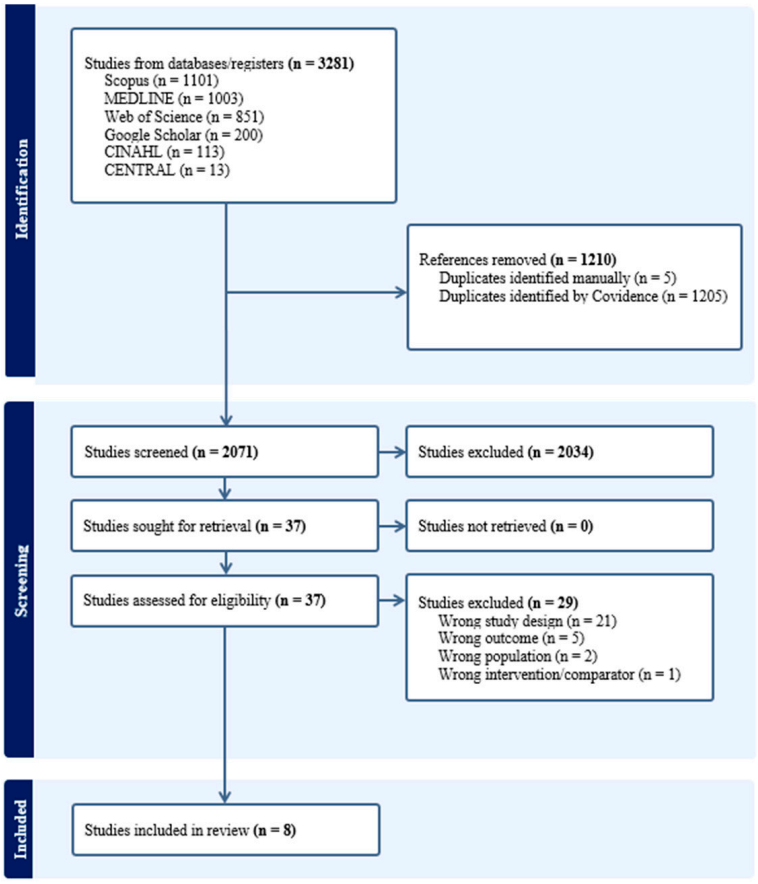

Figure 1. PRISMA flow diagram [27] Schematic representation of the flow of information throughout the phase of the systematic review process. Studies were included if they: (1) used a randomised or non-randomised controlled (crossover or parallel) trial design; (2) were conducted in humans aged 18 years or older; (3) involved the consumption of any rooibos tea extract supplement or rooibos tea beverage; (4) reported biochemical, physiological, anthropological and/or psychological markers at both baseline and end of intervention.

2.4. Data Extraction and Quality Assessment

The following characteristics from the included studies were recorded and organised into a pre-defined table: author and year of publication, aim of study, study design, sample size and percentage female, age of participants, intervention and comparator groups, data collection points and marker(s) assessed, results (presented as percentages, mean ± SD and/or *p* values) and main findings (Table 1). Two authors (K.E.S. and A.J.M.) independently performed a risk of bias and quality assessment following the Cochrane Handbook for systematic reviews of interventions using the second version of the Cochrane Risk of Bias tool (RoB2) (Table 2) and the Cochrane Risk Of Bias in Non-randomised Studies of Interventions (ROBINS-I) tool (Table 3) [28–30]. For the RoB2, the following five domains were used to determine risk of bias: (1) bias arising from the randomisation process; (2) bias due to deviations from intended interventions; (3) bias from missing outcome data; (4) bias in measurement of the outcome; (5) bias in selection of the reported results [29]. Regarding the ROBINS-I, the following seven domains were used to determine risk of bias: (1) bias due to confounding; (2) bias in selection of participants into the study; (3) bias in classification of interventions; (4) bias due to deviations from intended interventions; (5) bias due to missing data; (6) bias in measurement of outcomes; (7) bias in selection of the reported result [30].

Table 1. Characteristics of included studies investigating the effects of rooibos consumption on markers of health.

Author (Year)	Aim	Study Design, Sample Size (*n*) and % Female	Age of Participants (Years)	Intervention and Comparator Groups	Data Collection Points and Markers Assessed	Main Findings
Chepulis et al. (2016) [24]	To measure the effects of antioxidant food extracts on postprandial glucose responses in healthy individuals	Crossover *n* = 10 100% female	Range: 19–43 Mean: 28 ± 4.2	Study 1: Glucose 1. Green tea capsule (1 g) 2. Amla berry capsule (700 mg) 3. Propolis BIO100 capsule (400 mg) 4. Grape seed capsule (500 mg) 5. Rooibos (U or F not specified) capsule (≥30% polyphenols) 6. Control (50 g carbohydrate) Study 2: Bread and Ham 1. Green tea capsule (1 g) 2. Amla berry capsule (700 mg) 3. Propolis BIO100 capsule (400 mg) 4. Grape seed capsule (500 mg) 5. Rooibos (U or F not specified) capsule (≥30% polyphenols) 6. Control (50 g carbohydrate + 25 g of ham)	Baseline and every 15 min for 2 h post-consumption Markers: Blood glucose and iAUC	↓↓ iAUC compared with glucose-only and white bread controls
Lim et al. (2021) [31]	To investigate the acute effect of grape seed, rooibos tea and olive leaf extracts on postprandial blood glucose and insulin in participants with prediabetes	Crossover *N* = 19 74% female	Mean: 65 ± 1.6	1. Placebo (not specified) 2. Grape seed extract (40 g dry grape seed + 10 g fresh grape seed per capsule) 3. Unfermented rooibos tea extract (at least 485 mg total polyphenols per capsule) 4. Olive leaf extract (3.5 g fresh leaf suspended in olive oil + 264 mg polyphenols per capsule) Prediabetes subgroups 1. Healthier 2. Less healthy	Baseline 1 (10-min pre-capsule consumption); Baseline 2 (0-min pre OGGT); 15, 30, 45, 60, 90 and 120 min post-OGTT Markers: Serum glucose and insulin measures	↔ glucose and insulin measures between all plant extracts and placebo; ↑ $iAUC_{glucose}$ in healthier subgroup and ↑ DI in less healthy subgroup
Villaño et al. (2010) [15]	To assess the effect of drinking rooibos tea on TAC, lipid triacylglycerols, cholesterol and glycaemia plasma levels in humans	Crossover *N* = 15 Not specified	Mean: 33 ± 5	1. Group A (500 mL water) 2. Group B (500 mL fermented rooibos tea) 3. Group C (500 mL unfermented rooibos tea)	Time 0, 30, 60, 120 and 300 min post-ingestion Markers: Fasting BGL, TG, TC, uric acid, TRAP	↔ TG, TC, uric acid; ↑ TRAP
Davies et al. (2019) [32]	To investigate whether rooibos tea has an ergogenic effect during a fatiguing arm strength test	Crossover *N* = 32 0% female	Mean: 22.2	1. Fermented rooibos capsule (~340 mg polyphenols capsule) 2. Placebo capsule (not specified)	Five bouts of exercise Markers: Peak torque extension, peak torque flexion, total work extension and total work flexion	↔ peak torque extension, peak torque flexion, total work extension, total work flexion

Table 1. *Cont.*

Author (Year)	Aim	Study Design, Sample Size (*n*) and % Female	Age of Participants (Years)	Intervention and Comparator Groups	Data Collection Points and Markers Assessed	Main Findings
Breiter et al. (2011) [33]	To identify the metabolites after administration of an aspalathin-rich, isolated active fraction and unfermented rooibos tea	Crossover *N* = 10 0% female	Range: 21–35 Mean: 25.3	1. Water (500 mL) 2. Unfermented rooibos tea (10 g rooibos extract in 500 mL water) 3. Isolated active fraction (500 mg isolated active fraction in 500 mL water)	Before consumption, 30, 60, 90, 120, 180, 300 and 480 min after consumption Marker: Serum antioxidant capacity	↓ antioxidant capacity for all groups following ingestions of all treatment drinks; ↔ serum antioxidant levels between groups
Utter et al. (2010) [34]	To evaluate the effects of rooibos tea, bottled water and a carbohydrate beverage on blood and urinary markers of hydration after acute dehydration in collegiate wrestlers	Crossover *N* = 23 0% female	Mean: 19.6 ± 0.3	1. Rooibos tea (6% or 60 g L^{-1})—U or F not specified 2. Regular bottled water (not specified) 3. Carbohydrate beverage (6% or 60 g L^{-1})	1. Pre-dehydration 2. Post-dehydration 3. 1 h after rehydration Markers: Urine specific gravity, urine osmolarity, plasma osmolarity and plasma volume	↔ in promoting rehydration
Persson et al. (2010) [35]	To investigate the effect of green tea, black tea and rooibos tea on ACE and NO	Crossover *N* = 17 47% female	Range: 20–31 Mean: 26	1. 10 g green tea in 400 mL water 2. 10 g black tea in 400 mL water 3. 10 g rooibos tea in 400 mL water—U or F not specified	Data collected before tea consumption, 30, 60 and 180 min after tea consumption Markers: BP, HR, serum ACE activity and serum nitrite	↓ ACE activity at 30-min and 60-min post consumption
Marnewick et al. (2011) [19]	To investigate the effect of rooibos on biochemical and oxidative stress parameters in adults at risk for cardiovascular disease	Crossover *N* = 49 65% female	Mean: 46.8 ± 9.7	1. Fermented rooibos (six, 200 mL cups/day; one tea bag per cup) 2. Water (six, 200 mL cups/day)	1. Washout 2. Post-rooibos consumption 3. Post-water consumption Markers: Serum markers of antioxidant activity and content (total polyphenols), lipid peroxidation, redox status, lipid profile, liver and kidney function and BP	↔ antioxidant capacity; ↑ plasma total polyphenols, ↓ CDs; ↓↓↓ TBARS, gluathtione, GSH:GSSG, LDL-C and triacylglycerol; ↑↑↑ HDL-C

Note: ↑ = significant increase ($p < 0.05$); ↑↑↑ = significant increase ($p < 0.001$); ↓ = significant decrease $p < 0.05$); ↓↓ = significant decrease ($p < 0.01$); ↓↓↓ = significant decrease ($p < 0.001$); ↔ = no significant change ($p > 0.05$); h, hour; iAUC, incremental area under the curve; OGTT, oral glucose tolerance test; DI, oral disposition index; BGL, blood glucose levels, TAC, total antioxidant capacity; TRAP, total radical-trapping antioxidant potential; ACE, angiotensin-converting enzyme; NO, nitric oxide; BP, blood pressure; HR, heart rate; LDL-C, low density lipoprotein cholesterol; TG, triacyclglycerols; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; GSSG, oxidised glutathione; GSH:GSSG, ratio of reduced to oxidised glutathione; TBARS, ratio of reduced to oxidised glutathione; CDs, conjugated dienes; U, unfermented; F, fermented.

Table 2. Quality assessment of randomised intervention studies.

Author (Year)	Randomisation	Carryover Effects	Assignment/Adherence to Intervention	Missing Outcome Data	Outcome Measurement	Selective Reporting	Overall Risk of Bias
Chepulis et al. (2016) [24]	Some concerns	Some concerns	Some concerns	Low	Low	Low	Some Concerns
Villaño et al. (2010) [15]	Some concerns	Low	Low	Low	Low	Low	Some Concerns
Persson et al. (2010) [35]	Some concerns	Some concerns	Some concerns	Low	Some concerns	Low	High
Davies et al. (2019) [32]	Some concerns	Some concerns	Some concerns	Low	Some concerns	Low	High
Breiter et al. (2011) [33]	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Low	High
Utter et al. (2010) [34]	Some concerns	Some concerns	Some concerns	Low	Some concerns	Low	High

Table 3. Quality Assessment of Non-Randomised Intervention Studies.

Author (Year)	Confounding	Participant Selection	Classification of Interventions	Intended Intervention	Missing Data	Outcome Measurement	Selective Reporting	Overall Bias
Lim et al. (2021) [31]	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Marnewick et al. (2011) [19]	Low	Low	Low	Low	Low	Low	Low	Low

3. Results

The initial search retrieved a total of 3281 records. After de-duplication and initial screening by title and abstract, a total of 37 full-text articles were screened for eligibility. From this, 29 articles were deemed as ineligible, resulting in a final eight studies selected for inclusion in the current review (Figure 1). All included studies were of crossover design [15,19,24,31–35].

3.1. Study Characteristics

Included studies were published between 2010 and 2021, and sample sizes ranged from 10–49 participants (Table 1) [15,19,24,31–35]. Participant characteristics of the included studies varied, with three studies consisting of only males [32–34], three studies including both males and females [19,31,35], one study including only females [24] and one study not specifying the sex of participants [15]. The mean age of participants ranged from 19 to 65 years, with most recruited participants below 40 years old. Most studies investigated the effects of rooibos herbal tea or rooibos extracts in healthy individuals, whilst two studies (25%) investigated the effects in a prediabetic population or in adults at risk of cardiovascular disease [19,31].

3.2. Interventions

Six of the eight (75%) crossover trials were randomised [15,24,32–35]. Three (37.5%) studies dispensed rooibos extract in capsule form, whilst the remaining five studies administered rooibos as a beverage [15,19,24,31–35]. Three studies (37.5%) investigated fermented rooibos [15,19,32], another three (37.5%) investigated unfermented rooibos [15,31,33] and three studies (37.5%) did not specify the rooibos variety [24,34,35]. The total polyphenolic content for the studies that specified it (ranging from 0.09–30%) and dose (ranging from 63 mg to 1500 mg) for the rooibos intervention groups were inconsistent across studies [15,24,32–35]. Washout periods were wide-ranging, with the shortest being two days and the longest being four weeks [24,35]. However, one study did not specify the washout period length [32]. Notably, from the studies that specified washout periods (n = 7), only two (28.5%) provided a rationale to support the implemented washout duration [19,24]. Seven studies (87.5%) implemented dietary guidelines and/or restrictions of the specific dietary patterns for participants to adhere to throughout the trial [15,19,24,31–35].

3.3. Outcome Measures

Six studies (75%) reported biological markers of cardiovascular disease via blood markers (glucose, lipid profile, antioxidant activity) [15,19,24,31,33,35]. Whereas one study included biological markers via urine (urine specific gravity, urine osmolarity) [34]. Three studies (37.5%) reported the effects of rooibos consumption on physiological markers, such as blood pressure, heart rate and muscle strength [19,32,35]. None of the included studies explored the potential effects of rooibos herbal tea or rooibos extract on anthropometric or psychological outcomes.

3.4. Risk of Bias

The risk of bias assessment for the six randomised intervention studies (Table 2) resulted in four "high" risk studies [32–35]. This was mainly attributed to a lack of detail surrounding randomisation, carryover effects, intervention design and outcome measure-

ment. Whilst the remaining two studies displayed "some concerns" [15,24]. Regarding the two non-randomised intervention studies (Table 3), one study was deemed as "moderate" risk due to the "confounding" and "selective reporting" domains [31], whereas the other revealed a "low" risk of bias [19].

3.5. Study Results

3.5.1. Effect of Rooibos Consumption on Blood and Urinary Biomarkers

From the seven studies that assessed blood biomarkers, four indicated that rooibos herbal tea or rooibos extracts had significant ($p < 0.05$) effects on biological blood parameters, inclusive of glucose, total antioxidant capacity, angiotensin-converting enzyme (ACE) activity, oxidative status, markers of liver and kidney function and lipid profiles [15,19,24,35]. More specifically, Chepulis et al. (2016) [24] found that consumption of an acute dose of rooibos extract containing $\geq$ 30% polyphenols (variety not specified) may improve cardiometabolic health outcomes by significantly decreasing the incremental area under the curve (iAUC) for blood glucose compared to control in a glucose (mean $\pm$ SD iAUC = 166.6 $\pm$ 20.7; reduction from control = 35.5%; $p < 0.005$) or white bread challenge (mean $\pm$ SD iAUC = 129.2 $\pm$ 33.6; reduction from control = 32.9%; $p < 0.005$) [24]. Similarly, Persson et al. (2010) reported inhibition of ACE activity at 30-min ($p < 0.01$) and 60-min ($p < 0.05$) following an acute dose (400 mL) of rooibos (variety not specified) compared with baseline levels [35]. Additionally, Marnewick et al. (2011) demonstrated that consumption of six cups daily of fermented rooibos herbal tea for a period of six weeks led to significantly increased total polyphenol content in blood (from 79.8 $\pm$ 16.9 mg/L to 89.8 $\pm$ 14.1 mg/L; $p < 0.001$), improved lipid peroxidation [reduced conjugated dienes levels (167.3 $\pm$ 29.5 nmol/mL vs. 108.8 $\pm$ 20.1 nmol/mL; $p < 0.05$) and thiobarbituric acid reactive substances (1.9 $\pm$ 0.6 mol/L vs. 0.9 $\pm$ 0.3 mol/L; $p < 0.001$)], improved redox status [total glutathione (797 $\pm$ 238 mol/L vs. 1082 $\pm$ 140 mol/L; $p < 0.001$) and improved ratio of reduced to oxidised glutathione (41 $\pm$ 14 vs. 76 $\pm$ 17; $p < 0.001$)] compared to water [19]. Improved lipid profiles post-rooibos consumption were also demonstrated by significantly decreased levels of serum low-density lipoprotein cholesterol (4.6 $\pm$ 1.3 mmol/L vs. 3.9 $\pm$ 0.7 mmol/L; $p < 0.001$) and triacylglycerols (1.7 $\pm$ 0.8 mmol/L vs. 1.2 $\pm$ 0.7 mmol/L; $p < 0.001$) and significantly increased high-density lipoprotein cholesterol (0.9 $\pm$ 0.1 mmol/L vs. 1.2 $\pm$ 0.2 mmol/L; $p < 0.001$) [19]. The study conducted by Villaño et al. (2010) showed that acute consumption of unfermented rooibos herbal tea (500 mL) was associated with a significant increase in total radical trapping antioxidant potential (+2.9%; $p < 0.01$) with respect to the control, indicating that rooibos consumption in this instance may increase physiological levels of circulating antioxidants [15]. However, there were no significant changes in triacylglycerols, total cholesterol, or uric acid ($p > 0.05$) following fermented or unfermented rooibos herbal tea consumption [15].

Two studies reported no significant improvements in blood biomarkers after the rooibos treatment [33,34]. Although Breiter et al. (2011) demonstrated significant decreases in serum antioxidant capacity following the consumption of an acute dose (500 mL) of unfermented rooibos herbal tea, the AUC did not significantly differ between groups [rooibos herbal tea (-2659 ± 1314 µmol Trolox equivalents (TE)/L/*h) vs. water (-2163 ± 1878 µmol TE/L/*h) vs. isolated active fraction (–1987 $\pm$ 2185 µmol TE/L/*h)] [33]. Similarly, Utter et al. (2010) reported that an acute dose of rooibos herbal tea (variety not specified) was not significantly more effective at promoting rehydration than bottled water or a carbohydrate beverage ($p > 0.05$) [34].

The final study, which investigated the effects of an acute dose of rooibos extract consumption on blood biomarkers, indicated mixed results [31]. In this study, participants attended four visits during which they consumed either a placebo (visit 1), grape seed extract (visit 2), unfermented rooibos extract (visit 3) or olive leaf extract (visit 4) followed by an oral glucose tolerance test and venous blood sampling [31]. The findings did not indicate significant differences in glycaemic outcomes (Table 1) between the rooibos tea extract, alternative plant extracts and control groups (Table S2). However, when participants were

stratified (post-intervention) into prediabetes subgroups: (1) "healthier subgroup" and (2) "less healthy subgroup", rooibos extract appeared to improve the iAUC for glucose in the "healthier subgroup" ($p < 0.05$) as well as the oral disposition index (by insulin) in the "less healthy subgroup" ($p = 0.031$, 32.4% increase) [31]. Improvement in the oral disposition index may indicate an impedance in the development of Type II diabetes via enhanced glucose homeostasis [31]. However, grape seed extract and olive leaf extract appeared to be more effective than rooibos tea extract at improving postprandial serum glucose and insulin [31]. For grape seed extract, this was supported by a greater change in $iAUC_{glucose}$ ($p = 0.016$, 21.9% reduction), 2-h postprandial glucose ($p = 0.034$, 14.7% reduction), metabolic clearance rate of glucose ($p = 0.016$, 16.7% increase), 2-h postprandial insulin ($p = 0.029$, 22.4% reduction) and Stumvoll overall insulin sensitivity index ($p = 0.028$, 15.0% increase) compared with the placebo [31]. Whereas the olive leaf extract significantly increased the $iAUC_{insulin}$ ($p = 0.040$, 16.7%) [31].

The only study that included urinalysis found that an acute dose of rooibos (variety not specified) was not significantly more effective at improving urinary markers of hydration than the other beverages (water and a carbohydrate drink) included in the intervention ($p > 0.05$) [34].

3.5.2. Effect of Rooibos Consumption on Blood Pressure, Heart Rate and Muscle Strength

The two studies that investigated the effect of rooibos herbal tea consumption on blood pressure and heart rate did not demonstrate significant results compared with control groups or alternative treatments (Table S2) [19,35]. The study that investigated muscle strength using a maximal fatiguing elbow flexion/extension exercise protocol on a Biodex System 3 dynamometer showed improved performance during arm flexion (peak torque and total work) following the consumption of fermented rooibos herbal tea; however, the improvement was not significant ($p \geq 0.05$) [32].

4. Discussion

The results from this systematic literature review present mixed findings, with half of the included studies ($n = 4$) indicating significant effects between rooibos consumption and improved health outcomes [15,19,24,35]. The remaining four studies mainly demonstrated statistically insignificant results associated with rooibos consumption and improved health outcomes [31–34], with the exception of the study by Lim et al. (2021), in which blood glucose improved following consumption of rooibos extract when prediabetic participants were stratified into "healthier" and "less healthy" subgroups [31]. The subgroups were based on time to glucose and insulin peak following an oral glucose tolerance test, with the "less healthy" subgroup exhibiting more delayed insulin secretion and raised $AUC_{glucose}$ compared with the "healthier" subgroup [31].

4.1. Rooibos Consumption and Cardiometabolic Indicators of Health

Significant effects were observed after rooibos consumption and improvements in blood parameters associated with cardiometabolic health, such as improved blood glucose, lipid profiles and antioxidant status and inhibited ACE activity. However, there were no changes observed in urinary or physiological markers (blood pressure, heart rate and muscle strength) after rooibos herbal tea or extract consumption when compared with placebo or alternative treatments. Importantly, there was a scarcity of studies that measured markers beyond that of serum. This makes it difficult to discern the effects of rooibos consumption on additional markers, such as those related to the stress response, anthropometry, cardiorespiratory fitness, behaviour or psychological wellbeing.

One possible explanation for the observed effects of rooibos supplementation on markers of cardiometabolic disease risk may be the strong antioxidant capacity of rooibos herbal tea and supplements [36]. Previous findings have demonstrated that antioxidant-rich diets and supplementations may enhance insulin sensitivity and lipoprotein metabolism, decrease oxidative stress, inflammation and endothelial dysfunction, potentially leading

to reduced risk of cardiovascular disease, cancer and neurodegenerative diseases [24,37]. Although studies in humans are limited, animal models of cardiovascular disease have shown positive effects of rooibos supplementation on cardiometabolic outcomes [22,38–41]. Specifically, rooibos extract supplementation exhibited lipid-lowering properties and hypoglycaemic effects in different rat and mouse models [22,40,41]. Interestingly, these effects were only apparent or augmented when rooibos extract was administered in co-therapy with pharmacological treatments. For instance, Dludla et al. (2018) [21] showed that a combination of Metformin (primarily prescribed to manage Type II diabetes) and rooibos was more effective at treating hyperglycaemia than Metformin alone [21].

The polyphenolic composition of rooibos herbal tea and the high levels of aspalathin (unique to rooibos), especially in green rooibos, may be one of the main reasons that can be ascribed to the potential beneficial health outcomes [36]. More specifically, aspalathin may reduce the risk of developing cardiometabolic disease by facilitating carbohydrate digestion through the inhibition of α-glucosidase and/or α-amylase, or via augmenting β-cell function, thereby decreasing blood glucose levels [31,42]. The presence of aspalathin may exert cardioprotective effects by activating AMP-activated protein kinase (AMPK) [43]. Therefore, the increased activation of AMPK via rooibos consumption may both acutely impact cellular growth and metabolism as well as lead to long-term metabolic reprogramming, particularly in liver, fat and muscle tissues [44].

Several of the included studies used varying treatments (other teas/beverages, plant extracts) in addition to rooibos, apart from the control [24,31,33–35]. This is relevant since most of those studies demonstrated that the alternative treatment groups had either equal or greater potential than the rooibos group to improve markers of health (Table S2) [24,31,33,34]. For instance, Lim et al. (2021) [31] found that grape seed extract was more effective at managing glucose and insulin response compared to rooibos extract [31]. In another study, rooibos extract was comparable to alternative treatment groups (green tea, alma berry and grape seed) for modulating glycaemia [24]. Therefore, it is plausible that some of the alternative treatments used, such as grape seed, contain higher concentrations of bioactives that may exhibit more pronounced hypoglycaemic effects than rooibos herbal tea or rooibos extract [45,46].

4.2. Limitations

Although the included studies exhibited beneficial health outcomes as a result of consuming rooibos, the findings of this systematic review should be interpreted with caution. Importantly, an information specialist (M.T.) was consulted in this review to develop and validate the search terms and methodology, with only eight studies qualifying for inclusion in this review. One of the eligibility criteria was that included studies had to have a randomised or non-randomised controlled (crossover or parallel) trial design. Given this criterion, it is possible that studies of a different design were missed. Similarly, some studies were excluded given the low age cut-off of 18 years old. Consequentially, the generalisability, validity and reliability of results are limited. The authors also attempted to include possible studies investigating a wide array of health markers. However, it appears that research in rooibos tea beyond cardiometabolic and some physiological markers in humans (e.g., psychological, neurological, anthropometrical, etc.) is relatively scarce. In addition to the narrow scope of health markers reported, most studies were deemed as having a high or moderate risk of bias. There was also substantial heterogeneity between study designs, which may influence the findings. Despite all studies performing crossover trials, the dose variation was rather large (63 mg to 1500 mg), and washout periods were inconsistent (48 h to four weeks) [15,19,24,31–35]. This may be seen as problematic since levels of rooibos active ingredients are influenced by the route of treatment delivery (capsule vs. tea leaves vs. tea bag), steeping time and water volume (if rooibos was consumed as a beverage) [11]. Additionally, failure to control for physical activity levels and diet outside of the trial may confound results, as these factors can affect the evaluated health outcomes via modulation of the gut microbiota, among other routes [47]. Regarding the

included studies, whilst all but one attempted to control for diet, efforts to control for physical activity were minimal [15,19,24,31–35]. Other methodological limitations included small sample sizes and, in some cases, participant loss due to blood collection issues [31,35]. Finally, the type of rooibos (fermented vs. unfermented) was not standardised and nearly half of the included studies did not describe which rooibos variety was used [24,34,35]. Consequentially, there is insufficient evidence to determine if one type of rooibos is more healthful than the other.

4.3. Implications and Future Research

Interest in nutraceuticals as an attainable method for improving chronic health conditions is expanding as their potential applications are increasing [48,49]. Additionally, consumer demands, including those related to diet and lifestyle for the management of some chronic conditions, are increasing towards the use of naturally derived supplements and beverages such as rooibos herbal tea [32,48]. Rooibos has garnered interest as a supplement mainly for applications related to cardiometabolic conditions (Type II diabetes, hypertension, inflammation) [49]. However, preclinical research has demonstrated that rooibos may be useful for managing other health conditions, such as those related to mood, stress, cognition and/or sleep [50]. As such, there is a necessity for more high-quality randomised controlled trials conducted in humans that not only examine cardiometabolic outcomes but also those related to mental/neurological health. Further, the green, unfermented, rooibos variety is relatively unresearched despite its higher polyphenolic content and antioxidant properties than the red variety, representing a potential missed opportunity. Future trials should also examine the effects of rooibos on additional key and emerging biomarkers, such as those pertaining to the microbiome, saliva, urine and autonomic nervous system [51,52].

5. Conclusions

With the prevalence of chronic health conditions on the rise and a growing consumer and scientific community interest in the use of nutraceuticals to assist in the prevention and management of these conditions, it is important to investigate the effects of rooibos on health outcomes, given its high polyphenolic content and wide-ranging health properties demonstrated in pre-clinical models. The results from the current review suggest potential benefits of rooibos in humans, particularly related to measures of cardiometabolic health. However, with limited studies and mixed results, there is insufficient evidence to definitively support the potential health benefits. As such, there is a clear need for more well-designed trials investigating the effects of rooibos consumption on a wider array of physical and mental health outcomes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/beverages10040113/s1, Table S1: Search strategy; Table S2: Characteristics of included studies investigating the effects of rooibos tea and comparators on markers of health; PRISMA 2020 Checklist; PRISMA 2020 Abstract Checklist.

Author Contributions: Conceptualisation, K.E.S., A.J.M., and N.N.; validation, K.E.S., M.T., A.J.M., and N.N.; formal analysis, K.E.S., M.T., A.J.M., and N.N.; investigation, K.E.S. and M.T.; resources, K.E.S., A.J.M., and N.N.; data curation, K.E.S. and A.J.M.; writing—original draft, K.E.S.; writing—review and editing, K.E.S., J.L.M., S.E.H.D., M.T., V.L.N., R.D., A.J.M., and N.N.; visualisation, K.E.S., A.J.M., and N.N.; supervision, A.J.M. and N.N.; supervision, A.J.M. and N.N.; funding acquisition, A.J.M. and N.N. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by ADM Health & Wellness (Grant number: UC-R01583).

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors, Victoriya L. Nikolova and Richard Day, are full-time employees of ADM (Pty/Ltd.), and they had no role in the design of the study, data collection, analysis, interpretation of data or in the decision to publish the results. Kathryn Speer is a post-doctoral researcher working at the University of Canberra on a project funded by ADM (Pty/Ltd.). Nenad Naumovski and Andrew McKune have received the funding from the ADM (Pty/Ltd.) and all funds are registered with the University of Canberra Research Office (UC-RO-1583). All other authors declare no conflict of interest relating to this submission.

References

1. Yi, M.; Wu, X.; Zhuang, W.; Xia, L.; Chen, Y.; Zhao, R.; Wan, Q.; Du, L.; Zhou, Y. Tea consumption and health outcomes: Umbrella review of meta-analyses of observational studies in humans. *Mol. Nutr. Food Res.* **2019**, *63*, 1900389. [CrossRef] [PubMed]
2. Hogenkamp, P.S.; Jerling, J.C.; Hoekstra, T.; Melse-Boonstra, A.; MacIntyre, U.E. Association between consumption of black tea and iron status in adult Africans in the North West Province: The THUSA study. *Br. J. Nutr.* **2008**, *100*, 430–437. [CrossRef] [PubMed]
3. Abe, S.K.; Inoue, M. Green tea and cancer and cardiometabolic diseases: A review of the current epidemiological evidence. *Eur. J. Clin. Nutr.* **2021**, *75*, 865–876. [CrossRef] [PubMed]
4. Vuong, Q.V. Epidemiological evidence linking tea consumption to human health: A review. *Crit. Rev. Food Sci. Nutr.* **2014**, *54*, 523–536. [CrossRef] [PubMed]
5. Bendall, D.S. A Historical View of Tea. *Sci. Cult.* **2011**, *77*, 353–361.
6. Chieng, D.; Kistler, P.M. Coffee and tea on cardiovascular disease (CVD) prevention. *Trends Cardiovasc. Med.* **2022**, *32*, 399–405. [CrossRef]
7. Banerjee, P.; Ray, D.P. Functional food: A brief overview. *Int. J. Bioresour. Sci.* **2019**, *6*, 57–60. [CrossRef]
8. Shin, S.; Lee, J.E.; Loftfield, E.; Shu, X.O.; Abe, S.K.; Rahman, M.S.; Saito, E.; Islam, M.R.; Tsugane, S.; Sawada, N.; et al. Coffee and tea consumption and mortality from all causes, cardiovascular disease and cancer: A pooled analysis of prospective studies from the Asia Cohort Consortium. *Int. J. Epidemiol.* **2022**, *51*, 626–640. [CrossRef]
9. Zhang, C.; Qin, Y.-Y.; Wei, X.; Yu, F.-F.; Zhou, Y.-H.; He, J. Tea consumption and risk of cardiovascular outcomes and total mortality: A systematic review and meta-analysis of prospective observational studies. *Eur. J. Epidemiol.* **2015**, *30*, 103–113. [CrossRef]
10. de Souza, J.G.; Del Coso, J.; Fonseca, F.d.S.; Silva, B.V.C.; de Souza, D.B.; da Silva Gianoni, R.L.; Filip-Stachnik, A.; Serrão, J.C.; Claudino, J.G. Risk or benefit? Side effects of caffeine supplementation in sport: A systematic review. *Eur. J. Nutr.* **2022**, *61*, 3823–3834. [CrossRef]
11. Piek, H.; Venter, I.; Rautenbach, F.; Marnewick, J.L. Rooibos herbal tea: An optimal cup and its consumers. *Health SA* **2019**, *24*, 1090. [CrossRef] [PubMed]
12. Sibanda, M. Evaluation of the Therapeutic Potential of Green Rooibos (*Aspalathus linearis*) Extract in Neurological Disease. Master's Thesis, Stellenbosch University, Stellenbosch, South Africa, 2021.
13. Joubert, E.; de Beer, D. Rooibos (*Aspalathus linearis*) beyond the farm gate: From herbal tea to potential phytopharmaceutical. *S. Afr. J. Bot.* **2011**, *77*, 869–886. [CrossRef]
14. Damiani, E.; Carloni, P.; Rocchetti, G.; Senizza, B.; Tiano, L.; Joubert, E.; de Beer, D.; Lucini, L. Impact of cold versus hot brewing on the phenolic profile and antioxidant capacity of rooibos (*Aspalathus linearis*) herbal tea. *Antioxidants* **2019**, *8*, 499. [CrossRef] [PubMed]
15. Villaño, D.; Pecorari, M.; Testa, M.F.; Raguzzini, A.; Stalmach, A.; Crozier, A.; Tubili, C.; Serafini, M. Unfermented and fermented rooibos teas (*Aspalathus linearis*) increase plasma total antioxidant capacity in healthy humans. *Food Chem.* **2010**, *123*, 679–683. [CrossRef]
16. Pyrzanowska, J.; Fecka, I.; Mirowska-Guzel, D.; Joniec-Maciejak, I.; Blecharz-Klin, K.; Piechal, A.; Wojnar, E.; Widy-Tyszkiewicz, E. Long-term administration of *Aspalathus linearis* infusion affects spatial memory of adult Sprague-Dawley male rats as well as increases their striatal dopamine content. *J. Ethnopharmacol.* **2019**, *238*, 111881. [CrossRef]
17. Schloms, L.; Smith, C.; Storbeck, K.H.; Marnewick, J.L.; Swart, P.; Swart, A.C. Rooibos influences glucocorticoid levels and steroid ratios in vivo and in vitro: A natural approach in the management of stress and metabolic disorders? *Mol. Nutr. Food Res.* **2014**, *58*, 537–549. [CrossRef]
18. Hesseling, P.B.; Joubert, J.R. The effect of rooibos tea on the type I allergic reaction. *S. Afr. Med. J.* **1982**, *62*, 1037–1038.
19. Marnewick, J.; Rautenbach, F.; Venter, I.; Neethling, H.; Blackhurst, D.; Wolmarans, P.; Macharia, M. Effects of rooibos (*Aspalathus linearis*) on oxidative stress and biochemical parameters in adults at risk for cardiovascular disease. *J. Ethnopharmacol.* **2011**, *133*, 46–52. [CrossRef]
20. Shindo, Y.; Kato, K. Effect of rooibos tea on some dermatological diseases. In Proceedings of the International Symposium on Tea Science, Shizuoka, Japan, 26–29 August 1991; pp. 385–389.
21. Dludla, P.V.; Gabuza, K.B.; Muller, C.J.F.; Joubert, E.; Louw, J.; Johnson, R. Aspalathin, a C-glucosyl dihydrochalcone from rooibos improves the hypoglycemic potential of metformin in type 2 diabetic (db/db) mice. *Physiol. Res.* **2018**, *67*, 813–818. [CrossRef]

22. Dludla, P.V.; Muller, C.J.F.; Louw, J.; Mazibuko-Mbeje, S.E.; Tiano, L.; Silvestri, S.; Orlando, P.; Marcheggiani, F.; Cirilli, I.; Chellan, N.; et al. The Combination Effect of Aspalathin and Phenylpyruvic Acid-2-O-β-D-glucoside from Rooibos against Hyperglycemia-Induced Cardiac Damage: An In Vitro Study. *Nutrients* **2020**, *12*, 1151. [CrossRef]
23. Breet, P.; Kruger, H.S.; Jerling, J.C.; Oosthuizen, W. Actions of black tea and Rooibos on iron status of primary school children. *Nutr. Res.* **2005**, *25*, 983–994. [CrossRef]
24. Chepulis, L.; Al-Aubaidy, H.; Page, R. Effects of selected antioxidant food extracts on postprandial glucose responses in healthy individuals. *Funct. Foods Health Dis.* **2016**, *6*, 493–505. [CrossRef]
25. Marnewick, J.L.; Venter, I.; Rautenbach, F.; Neethling, H.; Kotze, M. Rooibos: Effect on Iron Status in South African Adults at Risk for Coronary Heart Disease. In *African Natural Plant Products Volume II: Discoveries and Challenges in Chemistry, Health, and Nutrition*; ACS Publications: Washington, DC, USA, 2013; pp. 103–114.
26. Sinisalo, M.; Enkovaara, A.L.; Kivistö, K.T. Possible hepatotoxic effect of rooibos tea: A case report. *Eur. J. Clin. Pharmacol.* **2010**, *66*, 427–428. [CrossRef] [PubMed]
27. Page, M.J.; Moher, D.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ* **2021**, *372*, n160. [CrossRef]
28. Higgins, J.P.; Savović, J.; Page, M.J.; Elbers, R.G.; Sterne, J.A. Assessing risk of bias in a randomized trial. In *Cochrane Handbook for Systematic Reviews of Interventions*; Wiley: Hoboken, NJ, USA, 2019; pp. 205–228.
29. Jonathan, A.C.S.; Jelena, S.; Matthew, J.P.; Roy, G.E.; Natalie, S.B.; Isabelle, B.; Christopher, J.C.; Hung-Yuan, C.; Mark, S.C.; Sandra, M.E.; et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ* **2019**, *366*, l4898. [CrossRef]
30. Jonathan, A.C.S.; Miguel, A.H.; Barnaby, C.R.; Jelena, S.; Nancy, D.B.; Meera, V.; David, H.; Douglas, G.A.; Mohammed, T.A.; Isabelle, B.; et al. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* **2016**, *355*, i4919. [CrossRef]
31. Lim, W.X.J.; Gammon, C.S.; von Hurst, P.R.; Chepulis, L.; Mugridge, O.; Page, R.A. Hypoglycemic effects of antioxidant-rich plant extracts on postprandial glycemic responses in participants with prediabetes (GLARE study). *Funct. Foods Health Dis.* **2021**, *11*, 604–626. [CrossRef]
32. Davies, S.E.; Marnewick, J.L.; West, S.; Taliep, M.S.; Rautenbach, F.; Gamieldien, R. The efficacy of rooibos *Aspalathus linearis* as an ergogenic aid during exercise. *Int. J. Hum. Factors Ergon.* **2019**, *6*, 88–102. [CrossRef]
33. Breiter, T.; Laue, C.; Kressel, G.; Gröll, S.; Engelhardt, U.H.; Hahn, A. Bioavailability and antioxidant potential of rooibos flavonoids in humans following the consumption of different rooibos formulations. *Food Chem.* **2011**, *128*, 338–347. [CrossRef]
34. Utter, A.C.; Quindry, J.C.; Emerenziani, G.P.; Valiente, J.S. Effects of rooibos tea, bottled water, and a carbohydrate beverage on blood and urinary measures of hydration after acute dehydration. *Res. Sports Med.* **2010**, *18*, 85–96. [CrossRef]
35. Persson, I.A.; Persson, K.; Hägg, S.; Andersson, R.G. Effects of green tea, black tea and Rooibos tea on angiotensin-converting enzyme and nitric oxide in healthy volunteers. *Public Health Nutr.* **2010**, *13*, 730–737. [CrossRef] [PubMed]
36. Dludla, P.V.; Joubert, E.; Muller, C.J.F.; Louw, J.; Johnson, R. Hyperglycemia-induced oxidative stress and heart disease-cardioprotective effects of rooibos flavonoids and phenylpyruvic acid-2-O-β-D-glucoside. *Nutr. Metab.* **2017**, *14*, 45. [CrossRef] [PubMed]
37. Annuzzi, G.; Bozzetto, L.; Costabile, G.; Giacco, R.; Mangione, A.; Anniballi, G.; Vitale, M.; Vetrani, C.; Cipriano, P.; Corte, G.D.; et al. Diets naturally rich in polyphenols improve fasting and postprandial dyslipidemia and reduce oxidative stress: A randomized controlled trial123. *Am. J. Clin. Nutr.* **2014**, *99*, 463–471. [CrossRef] [PubMed]
38. Mazibuko, S.E.; Muller, C.J.; Joubert, E.; de Beer, D.; Johnson, R.; Opoku, A.R.; Louw, J. Amelioration of palmitate-induced insulin resistance in C_2C_{12} muscle cells by rooibos (*Aspalathus linearis*). *Phytomedicine* **2013**, *20*, 813–819. [CrossRef]
39. Mikami, N.; Tsujimura, J.; Sato, A.; Narasada, A.; Shigeta, M.; Kato, M.; Hata, S.; Hitomi, E. Green Rooibos Extract from *Aspalathus linearis*, and its Component, Aspalathin, Suppress Elevation of Blood Glucose Levels in Mice and Inhibit α-amylase and α-glucosidase Activities in vitro. *Food Sci. Technol. Res.* **2015**, *21*, 231–240. [CrossRef]
40. Patel, O.; Muller, C.J.F.; Joubert, E.; Rosenkranz, B.; Louw, J.; Awortwe, C. Aspalathin-rich green rooibos tea in combination with glyburide and atorvastatin enhances lipid metabolism in a db/db mouse model. *Front. Clin. Diabetes Healthc.* **2022**, *3*, 963489. [CrossRef]
41. Webster, I.; Imperial, E.G.; Westcott, C.; Strijdom, H. The cardiovascular effects of *Aspalathus linearis* supplementation in male Wistar rats receiving fixed-dose combination first-line antiretroviral therapy. *Cardiovasc. J. Afr.* **2019**, *30*, 95–102. [CrossRef]
42. Pandey, K.B.; Rizvi, S.I. Plant polyphenols as dietary antioxidants in human health and disease. *Oxid. Med. Cell Longev.* **2009**, *2*, 270–278. [CrossRef]
43. Pantsi, W.G.; Marnewick, J.L.; Esterhuyse, A.J.; Rautenbach, F.; van Rooyen, J. Rooibos (*Aspalathus linearis*) offers cardiac protection against ischaemia/reperfusion in the isolated perfused rat heart. *Phytomedicine* **2011**, *18*, 1220–1228. [CrossRef]
44. Mihaylova, M.M.; Shaw, R.J. The AMPK signalling pathway coordinates cell growth, autophagy and metabolism. *Nat. Cell Biol.* **2011**, *13*, 1016–1023. [CrossRef]
45. Kar, P.; Laight, D.; Rooprai, H.K.; Shaw, K.M.; Cummings, M. Effects of grape seed extract in Type 2 diabetic subjects at high cardiovascular risk: A double blind randomized placebo controlled trial examining metabolic markers, vascular tone, inflammation, oxidative stress and insulin sensitivity. *Diabet. Med.* **2009**, *26*, 526–531. [CrossRef] [PubMed]

46. Sochorova, L.; Prusova, B.; Cebova, M.; Jurikova, T.; Mlcek, J.; Adamkova, A.; Nedomova, S.; Baron, M.; Sochor, J. Health Effects of Grape Seed and Skin Extracts and Their Influence on Biochemical Markers. *Molecules* **2020**, *25*, 5311. [CrossRef] [PubMed]
47. Hasain, Z.; Che Roos, N.A.; Rahmat, F.; Mustapa, M.; Raja Ali, R.A.; Mokhtar, N.M. Diet and pre-intervention washout modifies the effects of probiotics on gestational diabetes mellitus: A comprehensive systematic review and meta-analysis of randomized controlled trials. *Nutrients* **2021**, *13*, 3045. [CrossRef] [PubMed]
48. Baker, M.T.; Lu, P.; Parrella, J.A.; Leggette, H.R. Consumer Acceptance toward Functional Foods: A Scoping Review. *Int. J. Environ. Res. Public. Health* **2022**, *19*, 1217. [CrossRef]
49. Nehme, R.; Chervet, A.; Decombat, C.; Longechamp, L.; Rossary, A.; Boutin, R.; Rousset, A.; Senejoux, F.; Vachias, C.; Auxenfans, C.; et al. *Aspalathus linearis* (Rooibos) Targets Adipocytes and Obesity-Associated Inflammation. *Nutrients* **2023**, *15*, 1751. [CrossRef]
50. Minné, D.; Stromin, J.; Docrat, T.; Engel-Hills, P.; Marnewick, J.L. The effects of tea polyphenols on emotional homeostasis: Understanding dementia risk through stress, mood, attention & sleep. *Clin. Nutr. ESPEN* **2023**, *57*, 77–88. [CrossRef]
51. Debnath, S.; Levy, T.J.; Bellehsen, M.; Schwartz, R.M.; Barnaby, D.P.; Zanos, S.; Volpe, B.T.; Zanos, T.P. A method to quantify autonomic nervous system function in healthy, able-bodied individuals. *Bioelectron. Med.* **2021**, *7*, 13. [CrossRef]
52. Urlacher, S.S.; Kim, E.Y.; Luan, T.; Young, L.J.; Adjetey, B. Minimally invasive biomarkers in human and non-human primate evolutionary biology: Tools for understanding variation and adaptation. *Am. J. Hum. Biol.* **2022**, *34*, e23811. [CrossRef]