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Impact of botanical fermented foods on metabolic biomarkers and gut microbiota in adults with metabolic syndrome and type 2 diabetes: a systematic review protocol

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ABSTRACT

Introduction Dysfunctional gut microbiota is a common finding in patients with metabolic syndrome (MetS) and type 2 diabetes mellitus (T2DM). Recent clinical trials have assessed whether botanical fermented foods (BFFs) have beneficial effects on metabolic biomarkers, inflammatory markers and gut microbiota. The aim of this review is to critically evaluate all randomised controlled trials (RCTs) of BFF for evidence of impact on the outcome measures of these disease states.

Methods and analysis Four electronic databases (Embase, MEDLINE, CENTRAL and Google Scholar) as well as the grey literature will be searched from inception to present without language or publication status restrictions applied. Eligible RCTs which have enrolled adult participants with T2DM, any MetS components or combinations of these components, treated prophylactically or therapeutically with any botanical fermented food intervention, compared with a control group (no intervention, placebo or active control) will be assessed. Primary outcomes are related to the target conditions, including metabolic biomarkers, inflammatory markers and gut microbiota composition/function. Using Covidence, two independent investigators will conduct title and abstract screening, followed by full-text screening to identify appropriate studies. Methodological quality of the trials will be assessed using the Cochrane risk of bias assessment tool. Findings will be summarised with a narrative synthesis of the differences between included studies. A meta-analysis will be conducted if sufficient data are obtained.

Ethics and dissemination Ethical approval is not required as primary data will not be collected. Results will be disseminated through peer-reviewed publication, conference presentations and press.

PROSPERO registration number CRD42018117766

Strengths and limitations of this study

- This is the first systematic review and meta-analysis assessing the effectiveness of botanical fermented foods (BFFs) for adults with type 2 diabetes mellitus, metabolic syndrome and its components.
- To ensure highest quality scientific data, the conduct of this review will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.
- Robust systematic methodology used to identify quality evidence will assist in elucidating whether BFFs are effective prevention and management tools for non-communicable metabolic diseases.
- This systematic review and meta-analysis will have inherent limitations related to included studies such as risk of bias, methodological inconsistencies and incomplete outcome data.
- Result interpretation may be affected by significant heterogeneity due to the vast differences between BFFs, trial administration issues and the variety of outcome measures.

INTRODUCTION

Diet alters the structure and activity of human gut microbiota,[1] with direct effects on host health.[2] Shifts in gut microbiota have been linked to host metabolism dysfunction and low-grade chronic inflammation; these disorders of metabolism are implicated in the development of obesity, metabolic syndrome (MetS) and type 2 diabetes mellitus (T2DM).[3–5] MetS affects >25% of all adults globally[6]; T2DM is the world's most prevalent endocrine disorder.[5] As such, cheap, effective dietary therapies are of great interest to researchers, clinicians and government bodies.

Fermented products of plant origin, or botanical fermented foods (BFFs), are a microbially diverse part of global traditional diets.[7] These indigenous traditional fermented foods (eg, kimchi, sauerkraut, tibicos, tempeh, miso, kombucha, natto and fermented olives), as well as newer functional fermented products such as red

yeast rice and functional kimchi, have been recognised as having beneficial effects on human health.[8 9] The diversity of such ferments and their ingredients means they are abundant in microbiota-accessible carbohydrates, food-associated microorganisms such as lactic acid bacteria, bacterial components and metabolites, bioactive compounds such as polyphenols, vitamins and minerals.[9 10] Besides the basic nutritional properties of BFF ingredients, fermentation itself may confer additional health benefits through interactions between the host and consumed live microorganisms (probiotics), or through the ingestion of food-associated microbe-produced metabolites (biogenics) and other products of fermentation.[11] These include secondary phytochemicals, bioactive peptides and other compounds which have been shown to affect blood pressure, immune responses, antioxidant activity, insulin sensitivity, fasting and postprandial blood glucose.[12] The action of human gut microbiota on fermented food components in the intestinal lumen also produces health-promoting compounds, such as fermentation of microbiota-accessible carbohydrates into short chain fatty acids.[8] Though relatively sparse compared with studies on fermented dairy products for human health, recent clinical trials of BFF support their role in the prevention and treatment of non-communicable chronic diseases,[9] including obesity, pre-diabetes, type 2 diabetes, lipid dysfunction, cardiovascular disease, inflammatory bowel disorders and mental health disorders.[8]

Although a recent review of BFF in relation to non-communicable diseases has been conducted,[9] as well as others critically reviewing the health benefits of fermented foods,[8] no systematic review of the impact of BFF on MetS and T2DM has been undertaken. The aim is to systematically review randomised controlled trials (RCTs) for evidence of the impact of BFF compared with control on gut microbiota and metabolic biomarkers in adult human subjects suffering from components of MetS or T2DM. If sufficient homogeneous studies are identified, meta-analysis of the pooled data from these trials will elucidate the overall effect.

METHODS

Eligibility criteria

The Population, Intervention, Comparison, Outcome, Study type (PICOS) acronym[13] was used in the determination of the inclusion and exclusion criteria for this review. We will select RCTs (S) investigating the impact of BFFs (I), compared with placebo, no intervention or active controls (C), on adults (P) with T2DM or MetS components, or any combination of these components (O). Inclusion and exclusion criteria are shown in table 1.

Types of studies

All human RCTs in any language will be included.

Types of participants

This review will include trials with adult participants suffering from T2DM, or any MetS components or combinations of these components (eg, obesity, hypertension, lipid dysfunction, glucose intolerance/pre-diabetes, non-alcoholic fatty liver disease).

Types of interventions and comparators

This review will include studies that evaluate traditional BFF (eg, kimchi, sauerkraut, tibicos, tempeh,

Table 1 Inclusion and exclusion criteria

Criteria	Inclusion criteria	Exclusion criteria
Population	Adults over 18 years old. Diagnosed with T2DM, or suffering from any MetS components or combinations of these components.	Children. Non-T2DM individuals. Healthy subjects not suffering from any MetS components.
Intervention	BFFs and beverages. May contain any concentration of any types of live microorganisms, or no live microorganisms at time of consumption. Sole intervention.	Single compound extracts. BFFs mixed with non-fermented ingredients. BFFs as part of whole diet interventions. Coffee, tea, chocolate, beer, wine, high alcoholic beverages.
Comparator	Placebo, no intervention or active control groups.	Any other type of intervention or comparison.
Outcome	Related to target conditions (T2DM, MetS). Changes in anthropometric measurements, blood pressure, lipid profile, glucose metabolism/glycaemic control, inflammatory markers, gut microbiota composition and metabolites.Others: liver markers, quality of life, mental health scales, adverse events.	Not related to target conditions.
Study design	All clinical randomised controlled trials.	All other study designs.
Language	All languages.	None.
Setting	All settings.	None.

BFFs, botanical fermented foods; MetS, metabolic syndrome; T2DM, type 2 diabetes mellitus.

kombucha), as well as modern functional BFF (eg, functional kimchi, red yeast rice) made with specific microbial strains or additional beneficial ingredients. These plant-derived interventions may contain any concentration of any types of live microorganisms, measured in colony forming units; BFF interventions without live microorganisms at time of consumption will also be included. Studies that use BFF as the sole intervention will be considered. Single compound extracts, BFFs mixed with non-fermented ingredients and BFFs as part of whole diet interventions will be excluded. Coffee, tea, chocolate, beer, wine and other high alcoholic beverages will not be included.

Participants in the sample will have been randomly allocated into intervention (BFF) and placebo, no intervention or active control groups.

Types of outcome measures

We will search for all published quantitative research based on one or more included outcome measures. Outcome measures will be related to the target conditions, including, but not limited to changes in:

1. Weight as measured via waist circumference, body mass index and weight
2. Blood pressure (diastolic and systolic).
3. Lipid profile (fasting serum total cholesterol, high-density lipoprotein, low-density lipoprotein, triglycerides, free fatty acids)
4. Glucose metabolism (glycated haemoglobin, fasting plasma glucose, serum C-peptide, serum insulin).
5. Inflammatory markers (fasting serum high sensitivity C reactive protein, IL-6, IL-1B, tumour necrosis factor alpha).
6. Gut microbiota composition and metabolites (faecal metabolome, ribosomal RNA sequencing).

Other outcomes include liver markers (fasting serum aspartate aminotransferase, alanine aminotransferase), quality of life, mental health scales and adverse events.

Search methods for study identification

Data searches

The following four electronic databases will be searched from inception to present: Embase via Ovid, MEDLINE via Ovid, and Cochrane CENTRAL and Google Scholar (first 200 relevancy ranked results). Reference lists in identified articles and reviews, as well as studies that cited these articles, will be searched with Scopus. We will also search the grey literature via trials registries and conference papers. When a study has unreported data, authors will be contacted for further information.

Search strategy

The search strategy will combine subject heading terms and text words for BFF (eg, fermented food, fermentation, red yeast rice) and subject heading terms and text words to capture MetS or T2DM (eg, MetS, obesity, hypertension, blood pressure, diabetes, pre-diabetes, hyperlipidaemia, microbiota, dysbiosis, inflammation/inflammatory). To retrieve RCTs, the Cochrane Highly Sensitive Search Strategy for MEDLINE will be used. No date or language limits will be applied. The MEDLINE draft search strategy is included as box 1.

Box 1 Draft search strategy for Medline

1. randomised controlled trial.pt.
2. controlled clinical trial.pt.
3. (randomized or randomised).ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. exp animals/not humans.sh.
11. 9 not 10
12. Metabolic Syndrome/
13. diabetes mellitus, type 2/or diabetes mellitus, lipoatrophic/
14. Hypertension/
15. Insulin Resistance/
16. INSULIN/
17. Blood Glucose/
18. blood pressure/
19. cholesterol, HDL/
20. cholesterol, LDL/
21. Non-alcoholic Fatty Liver Disease/
22. Dyslipidemias/
23. PREDIABETIC STATE/
24. obesity/ or obesity, abdominal/ or obesity, morbid/
25. overweight/
26. 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25
27. (metabolic syndrome* or metabolic disorder* or MetS or dyslipidemia* or dysglycemia* or hypertension or diabetes or prediabetes or neo diabetic or obesity or overweight or insulin or hyperlipidemia* or lipid or blood pressure or NAFLD or non-alcoholic fatty liver or microbiota or microbiome or microflora or flora or intestinal or dysbiosis or inflamm*).mp.
28. 26 or 27
29. FERMENTATION/
30. Fermented Foods/
31. (monascus or monacolin or red yeast rice or Korean diet).mp.
32. (fermented or fermentation).mp.
33. 29 or 30 or 31 or 32
34. 28 and 33
35. 11 and 34

Selection of studies

One author (MC) and a clinical librarian (HB) will develop and execute a strategic search strategy following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Two authors (MC and NL) will independently select articles to include by screening titles and abstracts, followed by full text assessment according to eligibility criteria. Duplicates will be removed and reasons for study exclusion will be recorded. Final eligibility will be determined through agreement between the two reviewers; resolution to

any disagreements will be achieved through discussion. Authors of trials will be contacted for clarification when necessary. All processes and data will be recorded using Covidence software.

Data extraction and management

Using Covidence, two authors (MC and NL) will extract and manage the following data from eligible publications: study design, BFF type and dosage, duration of intervention, sample size, population, subjects' characteristics (age, sex, body mass index, symptom types), baseline metabolic biomarkers/gut microbiota profile, medication use, adverse events, treatment outcomes and other information. If reported data are insufficient, the authors of these studies will be contacted. Any disagreements will be resolved through discussion between the two authors.

Risk of bias assessment

All included studies will be qualified using the Cochrane Collaboration's tool for risk of bias (ROB) assessment.[14] Domains will include random sequence generation, allocation sequence concealment, participant and outcome assessor blinding, incomplete outcome data, selective outcome reporting and other sources of bias. Each domain ROB will be classified as low, high or unclear risk.

Data synthesis

If sufficient RCTs with robust heterogeneous pooled data for each outcome are identified, meta-analysis will be conducted. We will assume risk ratio-derived summary estimates for dichotomous outcomes, and mean difference for continuous outcomes. Adoption of a random effect model will be considered for predicted clinical heterogeneity of BFF types. Expected inconsistencies across studies will require the use of I^2 statistics and Galbraith plots[14]; substantial heterogeneity is considered at a 50% cut-off point. Depending on number of retrieved studies and their sample size, subgroup analyses will be stratified according to participant disease category, type of BFF and control intervention.

Covidence will be used to create a summary of findings table. If >10 studies are identified, potential publication and small sample bias will be assessed with funnel plots and Egger's test.[15] We will strive to identify possible causes of asymmetry, such as poor methodology or inappropriate effect measures.

If insufficient RCTs are available for meta-analysis, we will complete a narrative synthesis of included studies, summarising the study characteristics and BFF effectiveness based on the specific results of the included studies. Subgroup analysis will also be conducted in this context.

Grading evidence quality

Quality of evidence for all included outcomes will be assessed using Grading of Recommendations Assessment, Development and Evaluation working group methodology.[16] Domains to be assessed: ROB, consistency, precision, directness, publication bias and any additional points; classification will be into four levels (high, moderate, low or very low).

Registration

To report this protocol, we used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses reporting guideline extension for systematic review protocols (PRISMA-P).[17] The PRISMA-P checklist for this protocol is available (online supplementary file 1). Methodology is informed by the Cochrane Handbook for Systematic Reviews of Interventions. A standard version of the protocol has been registered with the International Prospective Register of Systematic Reviews http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018117766, and will be updated as necessary.

Ethics and dissemination

Formal ethical approval is not required as no individualised data will be used; as such no privacy issues are apparent. Review findings will be disseminated through peer-reviewed publications (print and online) and conference presentations.

PATIENT AND PUBLIC INVOLVEMENT

No patients or public will be involved in this systematic review protocol.

DISCUSSION

As far as can be established, no systematic review of clinical studies focused on BFF for MetS and T2DM has been conducted. When completed, this review will provide a summary of current evidence and identify further gaps in the research. The findings have the potential to influence clinical management of these increasingly prevalent non-communicable metabolic diseases, as well as contribute to the inclusion of BFFs in global food guides. The results of this review will also inform our interventional trial design.

Contributors MC, EE and KH conceived the study. MC developed the criteria, performed the preliminary literature searches and wrote this review protocol, with assistance from NL. HB and MC designed and wrote the search strategy. KH, EE, HB and LJ supervised, advised on protocol design and revised the manuscript. All authors read and approved the final manuscript and order of authorship.

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