



Cardiovascular Health Potential of Bambara Groundnut (*Vigna subterranea*): A Focused Review of Current Evidence and Research Gaps

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Abstract

Cardiovascular diseases remain a major cause of premature mortality, and dietary control of blood pressure, atherogenic lipids, oxidative stress, inflammation and glycaemic dysregulation is important for prevention. Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is an underutilized African legume whose cardiovascular relevance has been investigated, but the evidence is dispersed across experimental systems. This focused narrative review evaluated the cardiovascular health potential of Bambara groundnut, with emphasis on lipid regulation, blood-pressure pathways, oxidative stress, inflammation, glycaemic control and the gut-heart axis. A focused narrative literature search was conducted through 18 September 2026 using PubMed, African Journals Online, publisher-indexed records and reference lists of relevant studies and reviews. Studies were eligible when Bambara groundnut, or a fraction, extract or diet derived from it, had a cardiovascular-relevant endpoint or a mechanistically interpretable pathway. Evidence was classified by experimental level and by whether it was directly Bambara-specific or extrapolated from other legumes. Of the 15 Bambara-specific primary studies synthesized, 11 were in vitro or in silico studies (mainly of antioxidant activity, enzyme inhibition and starch digestion), four were rodent feeding studies and none was a human intervention study. Rodent findings on plasma lipids were inconsistent: an early study reported exaggerated hypercholesterolaemia with a Bambara diet, whereas three later studies of co-formulated or fermented preparations reported improved lipid profiles that cannot be attributed to Bambara groundnut alone. No eligible human randomized controlled trial was identified in the databases and sources searched. The evidence therefore supports a plausible multi-pathway hypothesis rather than an established clinical effect. Controlled human intervention studies using standardized preparations, adequately powered designs and validated cardiovascular endpoints are required before health claims can be supported.

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1.0 Introduction

Cardiovascular diseases remain a major cause of premature mortality and continue to impose a substantial global health burden, while hypertension remains a major modifiable cardiovascular risk factor (World Health Organization, 2025a, 2025b). Diet can influence several cardiovascular risk pathways at the same time, including blood pressure, atherogenic lipids, oxidative stress, inflammation and glycaemia, although the evidence for legume-rich and plant-based dietary patterns differs by outcome and study design (Mendes et al., 2023; Quek et al., 2021; Reyneke et al., 2023; Thorisdottir et al., 2023; Vigiuliouk et al., 2019).

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is an underutilized African legume with increasing research interest because its seed contains proteins, fibre and resistant starch, phenolic compounds and other constituents that may interact with cardiovascular risk pathways (Azman Halimi et al., 2019; Chelangat et al., 2023; Majola et al., 2025; Ramatsetse et al., 2023). The relevance of these constituents is not that Bambara groundnut has already been shown to prevent myocardial infarction or stroke, but that experimental studies provide plausible links to angiotensin-converting enzyme (ACE) activity, oxidative stress, inflammatory signalling, lipid handling and postprandial metabolic control. For example, protein hydrolysates derived from Bambara groundnut have shown ACE-inhibitory activity in vitro, while Bambara groundnut extracts have demonstrated antioxidant and anti-inflammatory activities in cell-free assays (Adedayo et al., 2021; Arise et al., 2017; Oyeyinka et al., 2021; Saetang et al., 2025). More recently, ACE- and dipeptidyl peptidase-IV (DPP-IV)-inhibitory activities were reported in Bambara groundnut hydrolysate fractions, and peptides predicted to inhibit either enzyme were identified by liquid chromatography-tandem mass spectrometry (LC-MS/MS) and molecular docking (Saetang et al., 2025). Much of the Bambara-specific literature consists of enzyme assays and extract-based

measurements (Adedayo et al., 2021; Arise et al., 2017; Oyeyinka et al., 2021; Saetang et al., 2025). These data are mechanistically informative, but cardiovascular claims can be overstated when they are treated as clinical surrogates, because no validated assay reliably measures the antioxidant capacity of foods (Huang et al., 2005) and in vitro ACE inhibition does not always predict an antihypertensive effect in vivo (Vermeirssen et al., 2004). Some findings are also difficult to attribute to Bambara groundnut alone, because studies may use co-formulated diets, non-physiological extract concentrations or endpoints that are mechanistically related to, but distinct from, cardiovascular outcomes (Adedayo et al., 2021; Ademiluyi & Oboh, 2015; Tan et al., 2021).

Previous reviews have covered the nutritional composition and food-security potential of Bambara groundnut, including the suitability of its starch and fibre for managing diabetes and high cholesterol (Azman Halimi et al., 2019), and the effects of bioprocessing on its composition and food applications (Mashau et al., 2025). Ramatsetse et al. (2023) summarized its health benefits together with its antimicrobial and antioxidant properties. These reviews have broadly examined the nutritional, antioxidant and health-promoting properties of Bambara groundnut; however, a cardiovascular-specific synthesis that explicitly separates Bambara-specific experimental evidence from mechanisms inferred from the wider legume literature remains limited. The present review therefore focuses specifically on cardiovascular-relevant endpoints and evaluates the evidence according to experimental level and translational strength.

Three gaps motivate this review. The first is an evidence gap: direct human cardiovascular evidence for Bambara groundnut is limited. The second is a translation gap: most available studies are biochemical, extract-based or animal studies whose exposure conditions are difficult to relate to dietary intake. The third is a synthesis gap: evidence across the different cardiovascular pathways has not been integrated according to

evidence level, so the relative strength of support for each pathway is hard to compare. The third gap is the one that this review is designed to address.

This review evaluates the cardiovascular health potential of Bambara groundnut by critically examining Bambara-specific evidence on oxidative stress, renin-angiotensin system-related enzyme inhibition, lipid metabolism, glycaemic regulation and the gut-heart axis, while distinguishing mechanistic evidence from human clinical evidence.

2.0 Materials and Methods

2.1 Review design

This article is a focused narrative review. It was not designed or conducted as a systematic review, and no meta-analysis, pooled effect estimates or formal risk-of-bias score was generated. To make the process transparent, the sources, search terms, eligibility criteria, selection steps, evidence classification and appraisal approach are described below in enough detail for another researcher to approximately reproduce the search, following the elements that are used to judge the description of the literature search in narrative reviews (Baethge et al., 2019).

2.2 Information sources and search strategy

The evidence base was assembled from three sources of information. First, a literature search was conducted through 18 September 2026 in PubMed, African Journals Online (AJOL) and the publisher platforms ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, Cambridge Core, Emerald Insight, MDPI, Frontiers and Royal Society of Chemistry (RSC) Publishing. Second, the reference lists of relevant Bambara groundnut and cardiovascular reviews and studies were screened (backward citation searching); forward citation tracking was not performed. Third, a supplementary web-based search (general search engine, journal websites and institutional repositories) was run on 20 September 2026 to check the completeness of the evidence base and to verify

citations; it was restricted to records available on or before 18 September 2026. The sources and dates are given in Table 1.

Queries were entered as free-text searches without field restriction, that is, in all searchable fields. The core Boolean structure was: (“Bambara groundnut” OR “*Vigna subterranea*”) AND (cardiovascular OR hypertension OR “blood pressure” OR cholesterol OR “low-density lipoprotein cholesterol” OR “angiotensin-converting enzyme” OR antioxidant OR inflammation OR “endothelial function” OR “glycaemic control” OR “resistant starch” OR “gut microbiome” OR “short-chain fatty acids”). Recent direct Bambara groundnut studies were prioritized, while older cardiovascular literature was retained only when necessary to interpret a specific mechanism. Only English-language records were screened, no start date was applied, and only peer-reviewed journal articles were retained for synthesis. The supplementary search combined Bambara groundnut with cholesterol, lipid, blood-pressure, angiotensin-converting enzyme, glycaemic-index, rat, diabetic and randomized-trial terms.

2.3 Eligibility criteria

Inclusion criteria. Records were eligible when (i) the test material was Bambara groundnut (*Vigna subterranea*), a derived fraction (protein, hydrolysate, starch or fibre), an extract, an isolated constituent or a diet containing Bambara groundnut; (ii) the study reported a cardiovascular-relevant outcome or a mechanistically interpretable cardiovascular pathway, namely blood pressure or renin-angiotensin-related enzyme activity, plasma lipids, oxidative stress or inflammation markers, glycaemic or starch-digestion endpoints treated as risk pathways, or gut microbiota and short-chain fatty acid endpoints; (iii) the record was an original study (reviews of Bambara groundnut and of cardiovascular pathways were retained only for context and interpretation); (iv) the record was available on or before 18 September 2026; and

(v) the record was a peer-reviewed journal article written in English.

Exclusion criteria. Records were excluded when (i) the study had no cardiovascular-relevant endpoint or mechanistically interpretable cardiovascular pathway, for example agronomic, genetic, sensory or purely technological studies; (ii) Bambara groundnut was mentioned only incidentally; or (iii) the record duplicated another publication. Conference abstracts, theses and dissertations, and records that could not be verified from an accessible abstract or full text, were also excluded. When a study involved Bambara groundnut together with another major

ingredient, the cardiovascular finding was retained but treated as a co-formulation result rather than as evidence attributable to Bambara groundnut alone.

2.4 Study selection and data extraction

Records were screened by title and abstract and then at full-text level by a single reviewer (the author), so no inter-reviewer disagreements arose and no consensus procedure was needed. The absence of independent duplicate screening is acknowledged as a limitation (Section 4.5).

Table 1: Sources of information, search dates and purpose of each source.

Source	Search date	Search terms and fields	Purpose and outcome
PubMed	18 September 2026	Core Boolean string (Section 2.2); all fields	Primary search of the biomedical literature
African Journals Online (AJOL)	18 September 2026	Same core string; all fields	Search of journals published in Africa
Publisher platforms (ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, Cambridge Core, Emerald Insight, MDPI, Frontiers, RSC Publishing)	18 September 2026	Same core string; all fields	Retrieval of full texts and of records not found elsewhere
Reference lists of relevant studies and reviews (backward citation searching)	18 September 2026	Manual screening of reference lists	Identification of further Bambara-specific and background studies
Supplementary web search (general search engine, journal websites, institutional repositories)	20 September 2026	<i>Bambara groundnut</i> or <i>Vigna subterranea</i> with cholesterol, lipid, blood-pressure, angiotensin-converting enzyme, glycaemic-index, rat, diabetic and randomized-trial terms; records up to 18 September 2026	Completeness check and citation verification; two additional rodent studies identified (Ademiluyi & Oboh, 2015; Ademiluyi et al., 2019); no human randomized controlled trial identified

AJOL, African Journals Online; RSC, Royal Society of Chemistry. Stage-wise counts of records identified, screened and excluded are not reported, for the reason given in Section 2.4.

Because searching in a focused narrative review is iterative, with database searches, reference-list screening and web searches repeated as themes emerged, stage-wise counts of records identified, duplicates removed and records excluded were not generated and are not reported; figures reconstructed retrospectively could not be verified. The outcome of selection is reported instead. Fifteen Bambara-specific primary studies met the eligibility criteria and were synthesized (Table 2). In total, 56 sources are cited: the 15 primary studies, five Bambara groundnut reviews and composition studies, and 36 guidelines, systematic reviews, mechanistic and methodological papers and web sources. The last two groups were used only to interpret pathways and were classified as indirect or background evidence. For each primary study, the model, Bambara groundnut preparation, dose or exposure, endpoints, main finding and principal limitation were extracted by the same reviewer.

2.5 Critical appraisal and evidence classification

Because the heterogeneity of study designs precluded a formal risk-of-bias score, each Bambara-specific study was appraised qualitatively for the features that determine how it can be interpreted: sample size, experimental model, controls, dose or exposure, duration, preparation of the Bambara groundnut material, outcome validity, statistical reporting, co-formulation and physiological relevance. These features overlap with the domains of risk-of-bias tools for animal studies (Hooijmans et al., 2014) but were assessed narratively, without a score, and are tabulated so that the principal limitation of each study is visible (Tables 2 and 3). The general translational principles that apply across pathways are set out once in Section 4.1, and the pathway sections refer to them only where a pathway-specific limitation applies.

Evidence strength was categorized according to the highest level of direct evidence available for each pathway: biochemical or cell-free assay

evidence (including in silico prediction), cellular evidence, animal intervention evidence and human intervention evidence. Only in vitro, in silico and animal data obtained with Bambara-derived material were treated as Bambara-specific evidence. Evidence derived primarily from non-Bambara legumes, or from general fibre, resistant-starch and microbiome research, was classified as indirect evidence and was not considered Bambara-specific efficacy evidence. A pathway supported by a plausible mechanism but by no Bambara-specific data was classified as a hypothesis. The terms used in Table 4 are defined accordingly: direct mechanistic evidence is an assay or in silico result obtained with Bambara-derived material; direct physiological evidence is a physiological or biochemical outcome measured in animals fed Bambara-containing diets; indirect evidence is extrapolated from other foods or populations; and a hypothesis has no Bambara-specific data. In vitro enzyme and antioxidant assays were considered hypothesis-generating; animal dietary studies were considered intermediate translational evidence; and human intervention studies were treated as the level required for causal cardiovascular claims.

3.0 Results

3.1 Overview of the Bambara-specific evidence base

The principal contribution of this review is not the generation of new experimental data, but the integration and critical classification of existing Bambara-specific evidence according to cardiovascular pathway and translational level. Fifteen Bambara-specific primary studies were synthesized (Table 2): 11 in vitro or in silico studies, four rodent feeding studies and no human intervention study. The studies were unevenly distributed across pathways. Antioxidant, anti-inflammatory and enzyme-inhibition endpoints were the most frequently studied, plasma lipids were examined only in rodents, and no study measured blood pressure (BP), endothelial function, inflammatory

biomarkers or the gut microbiota in animals or humans fed Bambara groundnut.

In vitro and in silico studies form the largest part of the current Bambara-specific evidence base (Adedayo et al., 2021; Arise et al., 2017; Chinnapun & Sakorn, 2022; Mune Mune et al., 2018; Oyeyinka et al., 2021; Saetang et al., 2025). They are useful for identifying candidate mechanisms, screening peptide sequences and comparing processing conditions. The study by Saetang et al. (2025) represents an important advance because it combined enzyme assays, peptide identification and structural modelling, but even this integrated approach remains preclinical.

Animal evidence is smaller but more directly relevant to physiology. Four rodent feeding studies were identified. Two used hypercholesterolaemic rats (Dabai et al., 1996; Tan et al., 2021), one used streptozotocin-induced diabetic rats and measured lung ACE activity (Ademiluyi & Oboh, 2015), and one

used rats fed a 1 % cholesterol diet and measured liver lipid peroxidation (Ademiluyi et al., 2019). Their designs and findings differ markedly (Section 3.2 and Table 3). Human evidence is the principal gap.

The search did not identify a randomized controlled trial in which Bambara groundnut intake was assigned and cardiovascular biomarkers such as low-density lipoprotein cholesterol (LDL-C), apolipoprotein B (apoB), systolic blood pressure, flow-mediated dilation or C-reactive protein (CRP) were measured as prespecified outcomes. This statement applies to the databases and sources searched (Table 1) and does not exclude unpublished or unindexed trials. Observational inference from populations that consume Bambara groundnut is also difficult, because overall dietary patterns, socioeconomic conditions, physical activity, medication use and other exposures can confound associations.

Table 2: Bambara-specific primary studies synthesized in this review. Panel A gives the model, preparation, exposure and level of evidence; Panel B gives the endpoints, main finding and principal limitation of the same studies, in the same order

A. Study design, exposure and level of evidence

Study	Model	Bambara groundnut preparation	Dose or exposure	Level ^a
Dabai et al. (1996)	Sprague-Dawley rats (60 on cholesterol-containing diets plus 10 on a cholesterol-free control); 8 weeks	Bambara groundnut in a semi-purified diet (form not stated in abstract)	330 g/kg diet; cholesterol 10 g/kg and cholic acid 5 g/kg	Animal; direct (adverse direction)
Tan et al. (2021)	Female Sprague-Dawley rats (30 in five groups); 2 weeks induction, 8 weeks treatment	Cooked, dehulled Bambara groundnut powder, alone or mixed with soy powder	Daily dose not stated; 10% Bambara-90% soy mix	Animal; co-formulation
Ademiluyi and Oboh (2015)	Male Wistar rats with streptozotocin-induced diabetes (six groups of six); 14 days	Fermented Bambara groundnut condiment; fermented locust bean and soybean tested in parallel	Diet supplementation (level not stated in abstract)	Animal; direct (fermented)
Ademiluyi et al. (2019)	Male Wistar rats fed 1% cholesterol (five groups of six); 30 days	Fermented Bambara groundnut, soybean and African locust bean condiments	16% of diet	Animal; direct (fermented)
Arise et al. (2017)	Cell-free enzyme and radical assays	Protein hydrolysates (alcalase, trypsin, pepsin) and 10, 5, 3 and 1 kDa fractions	Assay concentrations	In vitro; direct mechanistic

Mune Mune et al. (2018)	Cell-free assays; simulated digestion; in silico	Protein isolate hydrolysed with alcalase, thermolysin or trypsin	Assay concentrations	In vitro, in silico; direct mechanistic
Saetang et al. (2025)	Cell-free assays; LC-MS/MS; docking	Protein isolate hydrolysed with Flavourzyme; membrane fractions (above 10 kDa to below 1 kDa)	6 and 8 mg/mL	In vitro, in silico; direct mechanistic
Adedayo et al. (2021)	Cell-free assays; UPLC-qTOF-MS	Methanolic extracts of whole and dehulled seeds, by seed-coat colour	Extract concentrations	In vitro; direct mechanistic
Oyeyinka et al. (2021)	Cell-free assays	Hot-water extracts of four seed-coat colours (cream, black, maroon, brown)	Extract concentrations	In vitro; direct mechanistic
Chinnapun and Sakorn (2022)	Cell-free assays	New luteolin glycoside isolated from seeds	Compound concentrations	In vitro; direct mechanistic
Oboh et al. (2009)	Cell-free assays	Fermented (4 days, 37 °C) and unfermented Bambara groundnut and three other legumes	Extract concentrations	In vitro; direct mechanistic
Afolabi et al. (2018)	In vitro digestion	Flour; native, annealed (50 °C, 48 h) and heat-moisture-treated (100 °C, 16 h) starch	Not applicable	In vitro; indirect risk pathway
Chinma et al. (2023)	In vitro digestion	Starch from raw and germinated (24–72 h) seeds	Not applicable	In vitro; indirect risk pathway
Mashau et al. (2026)	Cell-free assays; metabolite profiling	Flours from dehulled and malted seeds of three varieties (cream, brown, red)	Not applicable	In vitro; direct mechanistic
Venter et al. (2024)	Cell-free assays; plasmid DNA damage assay	Flour from microwave-pretreated, presoaked seeds	Not applicable	In vitro; direct mechanistic

B. Endpoints, main findings and principal limitations

Study	Endpoints	Main finding	Principal limitation
Dabai et al. (1996)	Plasma cholesterol (weeks 4 and 8); faecal steroids	Bambara diet exaggerated hyper-cholesterol-aemia; baked beans and butter beans lowered cholesterol more than peas or lentils	Severe cholera model; very high inclusion; effect sizes not stated in abstract
Tan et al. (2021)	Total cholesterol; body weight	Abstract: greatest improvement with 30% Bambara-70% soy mix; total cholesterol differed from normal-diet control in all legume groups ($p < 0.05$)	Soy-dominant matrix; abstract and methods name different groups; means graphical only; no LDL-C, HDL-C or TG
Ademiluyi and Oboh (2015)	Plasma lipids; lung ACE activity	Fermented legume diets lowered ACE activity, total cholesterol, TG and LDL-C and raised HDL-C versus diabetic controls; locust bean most potent	Results pooled across condiments in abstract; diabetic model; short duration; BP not measured
Ademiluyi et al. (2019)	Plasma lipids; ALT, AST, ALP; liver MDA	Lowered total cholesterol, TG, LDL-C, liver enzymes and MDA and raised HDL-C versus hyper-cholesterol-aemic controls; locust bean best	Pooled reporting; fermented products; short duration; effect sizes not in abstract
Arise et al. (2017)	ACE and renin inhibition; ABTS scavenging; linoleic acid peroxidation	Fractions below 1 kDa most active against ACE; alcalase hydrolysate inhibited renin by 59%	No digestion, absorption or in vivo data

Mune Mune et al. (2018)	ACE and DPP-IV inhibition; DPPH scavenging; ferrous chelation	ACE IC ₅₀ 52 µg/mL (alcalase); DPP-IV IC ₅₀ 1.73 mg/mL (alcalase, thermolysin); digestion reduced both activities	Peptides not tested in vivo; activity fell after simulated digestion
Saetang et al. (2025)	ACE and DPP-IV inhibition; peptide identification; docking	ACE inhibition about 70–80% at 8 mg/mL (highest above 10 kDa); DPP-IV highest at 5–10 kDa (about 60%); 191 peptides; ACE candidates –10.2 to –11.3 kcal/mol	Candidates predicted, not synthesized or tested; no digestion or absorption data
Adedayo et al. (2021)	TPC; flavanols, flavonols, anthocyanins; ORAC; FRAP	Whole-seed extracts had higher antioxidant activity; TPC 3.6–11.0 (whole) versus 2.7–3.2 (dehulled) GAE/g	Chemical assays; solvent extracts; no bioavailability data
Oyeyinka et al. (2021)	TPC, TFC; antioxidant, anti-inflammatory and anti-microbial assays	Cream type had markedly lower TPC; TPC and TFC depended on boiling time and grain type	Extract concentrations unrelated to plasma exposure
Chinnapun and Sakorn (2022)	DPPH and superoxide scavenging; lipoygenase and xanthine oxidase inhibition; FRAP; metal chelation	IC ₅₀ 2.25 µg/mL (DPPH), 9.8 µg/mL (superoxide) and 2.16 µg/mL (lipoygenase, more potent than nordihydroguaiaretic acid); low FRAP and chelation activity	Isolated compound; dietary abundance unknown
Oboh et al. (2009)	Free and bound phenols; radical scavenging; reducing power; lipid peroxidation inhibition	Fermentation increased free soluble phenols and antioxidant activities; fermented Bambara groundnut was the most promising condiment	Cell-free assays; four legumes studied together; no in vivo data
Afolabi et al. (2018)	Resistant and digestible starch; functional properties	Flour: 33% resistant and 11.63% digestible starch; heat-moisture treatment raised resistant starch of native starch	No glycaemic or cardio-vascular endpoint in vivo
Chinma et al. (2023)	Starch digestibility; resistant starch; physico-chemical properties	Resistant-starch content fell with germination time; all starches retained about 73% resistant starch	Isolated starch; in vitro only
Mashau et al. (2026)	Antioxidant properties; phenolic composition; metabolite profile	Malting raised total phenolic and flavonoid contents (highest TPC 0.43 mg GAE/g in malted brown and red flours); both processes raised protocatechuic and syringic acids in red flour but lowered most other phenolic acids	Antioxidant assays; no exposure data
Venter et al. (2024)	Cooking time; flour functionality; phenolic profile; radical scavenging; protection of plasmid DNA	Cooking time fell; individual flavonoids rose or fell; flours kept radical-scavenging activity and protected plasmid DNA from oxidative damage	Antioxidant assays only; no exposure data

^aLevel: in vitro, cell-free or in silico study; animal, rodent feeding study; direct, Bambara-derived material was tested in the model; indirect risk pathway, an endpoint that is a surrogate for glycaemic risk. ABTS, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid); ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; DPPH, 1,1-diphenyl-2-picrylhydrazyl; FRAP, ferric reducing antioxidant power; GAE, gallic acid equivalents; HDL-C, high-density lipoprotein cholesterol; IC₅₀, half-maximal inhibitory concentration; LDL-C, low-density lipoprotein cholesterol; LC-MS/MS, liquid chromatography-tandem mass spectrometry; MDA, malondialdehyde; ORAC, oxygen radical absorbance capacity; TFC, total flavonoid content; TG, triglycerides; TPC, total phenolic content; UPLC-qTOF-MS, ultra-performance liquid chromatography-quadrupole time-of-flight mass spectrometry. Values are those reported in the abstracts or open-access text of the cited studies.

3.2 Atherogenic lipid regulation

Atherogenic dyslipidaemia is a central modifiable pathway in atherosclerotic cardiovascular disease (ASCVD), with LDL-C and apoB-containing particles playing major roles in atheroma formation (Grundy et al., 2019; Libby et al., 2019). Bambara groundnut may interact with this pathway through several candidate mechanisms, but the quality of Bambara-specific evidence varies considerably.

The animal evidence comes from four rodent feeding studies (Table 3). Dabai et al. (1996) fed rats semi-purified diets containing cholesterol and cholic acid, in which a legume replaced 330 g/kg of the diet. Baked beans and butter beans lowered raised plasma cholesterol more than marrowfat peas or lentils, whereas inclusion of Bambara groundnut exaggerated hypercholesterolaemia. Tan et al. (2021) reported improved total cholesterol in hypercholesterolaemic female rats given Bambara-containing drink mixes for eight weeks. The abstract names the formulation with the highest Bambara proportion (30% Bambara, 70% soy powder) as the best performer, whereas the *in vivo* methods and figure legend describe groups given pure Bambara powder or a 10% Bambara-90% soy mix. Total cholesterol was the only lipid reported, and the text states that it differed significantly ($p < 0.05$) between the normal-diet control group and all legume-diet groups, with the simvastatin group showing the second-lowest value. The study is relevant because it measured circulating lipid concentrations rather than relying solely on a cell-free biochemical assay. Nevertheless, the mixed diets were dominated by soy powder, so the magnitude of any effect cannot be assigned specifically to Bambara groundnut. The study should therefore be interpreted as evidence that a Bambara-containing dietary matrix can influence cholesterol metabolism in an animal model, not as proof of a standalone hypocholesterolaemic effect (Tan et al., 2021).

Two later studies from one laboratory used fermented condiment diets. In streptozotocin-induced diabetic rats, diets supplemented with fermented Bambara groundnut, African locust bean or soybean significantly lowered lung ACE activity, plasma total cholesterol, triglycerides and LDL-C and raised HDL-C compared with diabetic controls, the locust bean diet being the most potent (Ademiluyi & Oboh, 2015). In rats fed 1% dietary cholesterol, diets containing 16% of the same fermented condiments lowered total cholesterol, triglycerides, LDL-C, liver enzymes and liver malondialdehyde and raised HDL-C relative to hypercholesterolaemic controls (Ademiluyi et al., 2019). In both studies the abstracts report the three condiments collectively and identify the locust bean diet as the best performer, so the size of any Bambara-specific effect cannot be isolated from the text that was accessible.

Numerical effect sizes could not be tabulated for these studies. Tan et al. (2021) present total cholesterol only as a bar chart, with no group means in the text or tables and no LDL-C, HDL-C or triglyceride data, and the abstracts of the other three studies report the direction and statistical significance of changes without effect sizes. Values were not digitized from figures because this would risk misreporting. Table 3 therefore reports the design attributes and the direction and significance of the reported changes, which are the details that can be verified.

At the mechanistic level, the lipid-lowering hypothesis is also supported by the broader literature on dietary fibre. Higher fibre intake was associated with lower total cholesterol and LDL-C, but not triglycerides, in an umbrella review of 52 meta-analyses of randomized trials (Fu et al., 2022), and soluble fibre supplementation reduced LDL-C, total cholesterol, triglycerides and apoB in a meta-analysis of 181 randomized trials (Ghavami et al., 2023).

Table 3: Design attributes and reported lipid outcomes of rodent studies of Bambara-containing diets.

Attribute	Dabai et al. (1996)	Tan et al. (2021)	Ademiluyi and Oboh (2015)	Ademiluyi et al. (2019)
Species, strain and sex	Sprague-Dawley rats; sex NR	Sprague-Dawley rats; female	Wistar rats; male	Wistar rats; male
Model	Semi-purified diet with cholesterol (10 g/kg) and cholic acid (5 g/kg); 40% of energy as fat	High-cholesterol diet for 2 weeks (composition NR)	Streptozotocin-induced diabetes (35 mg/kg)	Diet with 1% cholesterol
Animals	60 on cholesterol-containing diets plus 10 on a cholesterol-free control; group size NR	30 in five groups; group size NR	36 in six groups of six	30 in five groups of six
Duration of feeding	8 weeks (lipids at weeks 4 and 8)	8 weeks after 2 weeks of induction	14 days	30 days
Bambara groundnut preparation	NR	Cooked, dehulled, dried powder; alone or mixed with soy powder	Fermented condiment	Fermented condiment
Bambara groundnut inclusion	330 g/kg diet (dry matter)	Pure powder or 10% Bambara-90% soy mix (abstract also cites 30:70); daily quantity NR	NR	16% of diet
Other ingredients and comparators	Four other legumes; cholesterol-free and cholesterol-fed control diets	Soy powder (70–90% of mix); simvastatin group; normal-diet and untreated hyper-cholesterol-aemic groups	Fermented locust bean and soybean condiments; diabetic control	Fermented locust bean and soybean condiments; hyper-cholesterol-aemic control
Lipid and related endpoints	Plasma cholesterol; faecal steroids	Total cholesterol only; body weight	TC, TG, LDL-C, HDL-C; lung ACE activity	TC, TG, LDL-C, HDL-C; ALT, AST, ALP; liver MDA
Direction of reported effect	Cholesterol raised (exaggerated hyper-cholesterol-aemia)	Improvement reported; formulation named in abstract differs from groups in methods	Improvement (condiments pooled; locust bean best)	Improvement (condiments pooled; locust bean best)
Numerical effect sizes	NR in abstract	Graphical only	NR in abstract ($p < 0.05$)	NR in abstract ($p < 0.05$)

NR, not reported in the abstract or open-access text examined; ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MDA, malondialdehyde; TC, total cholesterol; TG, triglycerides.

Proposed mechanisms include reduced bile-salt re-absorption, a lower glycaemic response and effects of fermentation products, of which the bile-salt mechanism is the best supported (Gunness & Gidley, 2010). These data cannot be transferred quantitatively to Bambara

groundnut, but they provide a biological rationale for investigating it as a fibre-bearing legume. Evidence for direct modulation of hepatic cholesterol synthesis by Bambara-derived peptides remains insufficiently characterized.

Saponins are sometimes proposed as an additional cholesterol-related mechanism in edible legumes because they have been reported to lower cholesterol and other blood lipids (Shi et al., 2004). For Bambara groundnut specifically, however, direct evidence linking its native saponin fraction to lower LDL-C in humans is lacking. Future Bambara groundnut trials should therefore measure LDL-C, non-high-density lipoprotein cholesterol (non-HDL-C), high-density lipoprotein cholesterol (HDL-C), apoB and triglycerides rather than relying on total cholesterol alone (Grundy et al., 2019), while controlling background dietary fat, medication use and baseline metabolic status.

3.3 Blood pressure regulation and the renin-angiotensin system

Bambara groundnut protein hydrolysates have shown *in vitro* ACE-inhibitory activity, supporting the presence of peptide sequences capable of interfering with the renin-angiotensin-aldosterone system (RAAS) (Arise et al., 2017; Mune Mune et al., 2018; Saetang et al., 2025). ACE converts angiotensin I to angiotensin II and contributes to vasoconstriction and sodium-retaining responses (Ferrario, 2010). ACE inhibition is therefore a recognized biochemical pathway relevant to BP regulation, and ACE inhibitors are established antihypertensive drugs (McEvoy et al., 2024). Food-derived peptides that inhibit ACE have accordingly been studied as candidate antihypertensive ingredients (Majumder & Wu, 2015).

Arise et al. (2017) reported that peptide fractions below 1 kDa had the highest ACE-inhibitory activity for all three hydrolysates (alcalase, trypsin and pepsin) and that the alcalase hydrolysate inhibited renin by 59%. Mune Mune et al. (2018) reported ACE- and DPP-IV-inhibitory hydrolysates whose activities were significantly reduced by simulated gastrointestinal digestion, the thermolysin hydrolysate being the most resistant. More recently, Saetang et al. (2025) hydrolysed Bambara groundnut protein

isolate with Flavourzyme, fractionated the hydrolysate by molecular weight and identified 191 peptides by LC-MS/MS. All fractions inhibited ACE, the fraction above 10 kDa being the most active, and the 5–10 kDa fraction showed the strongest DPP-IV inhibition (Table 2). The authors identified YKDGLYSPHW, LPVSTPGKF and RPFLPPR as the top predicted ACE-inhibitory candidates, while EPWWPK was among the top predicted DPP-IV-inhibitory candidates, and docking predicted favourable interactions with the ACE catalytic site. These data strengthen the molecular case for Bambara-derived antihypertensive peptides, but the peptides were predicted and were not synthesized and tested individually. Molecular docking does not establish absorption, plasma exposure or BP lowering in humans. The critical next step is to establish whether these peptides survive gastrointestinal digestion, appear in circulation at relevant concentrations and alter validated haemodynamic endpoints. The cardiovascular interpretation of ACE inhibition should therefore remain proportional to the evidence. The available studies demonstrate enzyme inhibition and peptide-target interactions, not clinical antihypertensive efficacy. The only *in vivo* enzyme data for a Bambara-containing diet are those of Ademiluyi and Oboh (2015), in which lung ACE activity was lower in diabetic rats fed fermented Bambara groundnut, locust bean or soybean condiments than in diabetic controls; BP itself was not measured. The search did not identify a randomized human trial of Bambara groundnut intake measuring systolic or diastolic BP as a primary outcome. A meta-analysis of 16 randomized trials of non-oil seed legumes, with durations of 4 to 52 weeks, found no significant overall effect on BP (systolic mean difference -1.06 mm Hg; 95% confidence interval -2.57 to 0.44), so a BP benefit cannot be assumed for legumes as a category, and it is even less certain for Bambara groundnut (Reyneke et al., 2023). Consequently, Bambara groundnut should not presently be described as a dietary ACE inhibitor

or as a replacement for antihypertensive therapy. Instead, the evidence supports a testable hypothesis that specific Bambara groundnut peptide fractions may contribute to BP regulation when delivered in a physiologically accessible food matrix.

3.4 Oxidative stress, vascular inflammation and endothelial protection

Oxidative stress and vascular inflammation are closely connected to endothelial dysfunction and atherogenesis. Reactive oxygen species can promote low-density lipoprotein (LDL) oxidation, impair nitric oxide signalling and activate inflammatory transcriptional pathways, while cytokine-driven endothelial activation facilitates leukocyte recruitment and plaque progression (Förstermann et al., 2017; Libby et al., 2019; Ridker, 2016). Bambara groundnut extracts have shown antioxidant activity in several experimental systems. Adedayo et al. (2021) found that methanolic extracts of whole seeds generally showed greater oxygen radical absorbance capacity (ORAC) and ferric reducing antioxidant power (FRAP) activity than extracts of dehulled seeds, with total phenolic content of 3.6–11.0 gallic acid equivalents (GAE)/g in whole seeds and 2.7–3.2 GAE/g in dehulled seeds, and variation among seed-coat colours. This suggests that redox activity measured in vitro is sensitive to the part of the seed used and to extraction conditions.

Oyeyinka et al. (2021) similarly reported antioxidant and anti-inflammatory potential in hot-water extracts of four seed-coat colours, with substantially lower phenolic content in the cream type. Chinnapun and Sakorn (2022) isolated a luteolin glycoside from Bambara groundnut seeds and demonstrated 1,1-diphenyl-2-picrylhydrazyl (DPPH) and superoxide-radical scavenging together with inhibition of lipoxygenase. Oboh et al. (2009) reported that fermentation increased the free soluble phenol content of four underutilized legumes, including Bambara groundnut, and enhanced their radical scavenging, reducing

power and inhibition of lipid peroxidation, with fermented Bambara groundnut the most promising condiment. In vivo, liver malondialdehyde was lower in hypercholesterolaemic rats fed fermented condiment diets that included Bambara groundnut (Ademiluyi et al., 2019). Collectively, these findings show that Bambara groundnut contains constituents capable of modifying redox and inflammatory assays; they do not establish that eating Bambara groundnut reduces vascular oxidative stress in people (Section 4.1).

An additional mechanistic link is the nuclear factor erythroid 2-related factor 2 (Nrf2)-Kelch-like ECH-associated protein 1 (Keap1) antioxidant-response system, which regulates endogenous cellular defences and is implicated in cardiovascular disease biology (Dhyani et al., 2024). However, direct evidence that consumption of Bambara groundnut activates Nrf2 in human vascular tissue was not identified. The appropriate interpretation is therefore mechanistic: Bambara-derived phenolic compounds may have the capacity to influence oxidative and inflammatory pathways, but the clinical importance of these actions depends on bioavailability, metabolism, dose and tissue exposure. Future studies should measure endothelial function (for example by flow-mediated dilation performed to consensus standards; Thijssen et al., 2019), oxidized LDL, F2-isoprostanes, nitric-oxide bioavailability and inflammatory biomarkers rather than relying exclusively on chemical radical-scavenging assays.

3.5 Glycaemic regulation as a cardiovascular risk pathway

Hyperglycaemia, insulin resistance and metabolic dysfunction contribute to endothelial injury, oxidative stress and atherogenic risk (Low Wang et al., 2016). Bambara groundnut is relevant to this pathway primarily through its starch and protein matrix rather than through a diabetes-focused health claim. Hydrothermal

treatment changes the in vitro digestibility of Bambara groundnut starch and flour: Afolabi et al. (2018) reported that the flour contained 33% resistant starch and 11.63% digestible starch, and that heat-moisture treatment increased the resistant-starch content of the native starch. Chinma et al. (2023) reported that the resistant-starch content of isolated starch decreased with increasing germination time (0–72 h), although native and germinated starches all retained a high proportion of resistant starch (about 73%). More generally, a meta-analysis of 19 randomized trials found that resistant starch lowered fasting plasma glucose (effect size -0.09 mmol/L) and the homeostasis model assessment of insulin resistance (HOMA-IR) but not fasting insulin (Xiong et al., 2021). In a randomized trial of 121 adults with type 2 diabetes, a low-glycaemic-index diet emphasizing legumes (about 190 g per day) lowered glycated haemoglobin (HbA1c) by 0.5 percentage points, compared with 0.3 percentage points on a high-wheat-fibre diet, and reduced BP and estimated coronary heart disease risk, illustrating the potential cardiovascular relevance of legume-based dietary patterns without establishing a Bambara-specific effect (Jenkins et al., 2012).

Protein-derived DPP-IV inhibition provides a second possible connection. Bambara groundnut hydrolysates have shown DPP-IV-inhibitory activity in vitro (Mune Mune et al., 2018; Saetang et al., 2025), although simulated gastrointestinal digestion significantly reduced this activity in the hydrolysates studied by Mune Mune et al. (2018). Because hyperglycaemia is a cardiovascular risk amplifier rather than the principal outcome of this review, these observations are relevant only as an indirect risk pathway. Future trials should therefore pair BP and lipid outcomes with fasting glucose, HbA1c, insulin-resistance markers and postprandial glucose excursions to determine whether any cardiovascular benefit is accompanied by improved glycaemic control.

Evidence status: indirect. The evidence presented in this subsection should therefore be interpreted primarily as biological rationale for future Bambara-specific studies rather than evidence of a demonstrated cardiovascular effect.

3.6 Gut-heart axis: a hypothesis-generating pathway

The gut-heart axis is a plausible but unvalidated pathway, and it is the least directly supported of those considered here. Dietary fibre and resistant starch can be fermented to short-chain fatty acids (SCFAs), including acetate, propionate and butyrate, which influence intestinal barrier integrity, hepatic lipid metabolism, immune signalling and host energy regulation (Lu et al., 2022; Nogal et al., 2021). The gut microbiome is also linked to cardiovascular disease through permeability, inflammatory signalling and metabolite production (Tang & Hazen, 2017; Witkowski et al., 2020), and polyphenol-derived microbiota metabolites have been linked to cardiovascular-relevant pathways in human studies (Pinaffi-Langley et al., 2024). None of these data involves Bambara groundnut.

For Bambara groundnut, this pathway should currently be regarded as a hypothesis. The flour contains 33% resistant starch that can reach the colon (Afolabi et al., 2018), but the focused search did not identify a human intervention study showing that Bambara groundnut consumption alters SCFAs, microbial taxa and cardiovascular biomarkers in parallel. Future trials should combine stool microbiome sequencing, plasma or faecal SCFAs, bile-acid profiles and inflammatory markers with LDL-C and BP measurements.

3.7 Processing and translational relevance

The translational question is whether processing alters the amount and bioavailability of cardiovascular-relevant compounds at realistic dietary doses. Dehulling, fermentation, malting and other treatments alter phenolic composition, metabolite profiles, starch functionality and

antioxidant measurements (Afolabi et al., 2018; Mashau et al., 2025; Venter et al., 2024). Whole-seed extracts were more antioxidant than dehulled-seed extracts (Adedayo et al., 2021), fermentation increased free soluble phenol content (Obboh et al., 2009), and dehulling and malting changed metabolite profiles (Mashau et al., 2026). Effects on starch can run in either direction: heat-moisture treatment increased resistant starch (Afolabi et al., 2018), whereas germination reduced it (Chinma et al., 2023). These changes matter only if they alter exposure. An increase in ORAC or FRAP after fermentation reflects chemical reducing capacity, not reduced cardiovascular risk, and no study identified here measured the amount or bioavailability of specific cardiovascular-relevant molecules after a defined, reproducible processing method. Processing should therefore be standardized and reported in intervention studies.

3.8 Integrated evidence map

Table 4 and Figure 1 summarize the pathway-level evidence. The direct Bambara-specific evidence is unequal across pathways. ACE-inhibitory peptides provide the clearest direct molecular evidence for a potential blood-pressure-related mechanism (Arise et al., 2017; Mune Mune et al., 2018; Saetang et al., 2025); antioxidant and anti-inflammatory assays provide support for a vascular redox hypothesis (Adedayo et al., 2021; Chinnapun & Sakorn, 2022; Oyeyinka et al., 2021); and rodent studies provide preliminary and inconsistent evidence on circulating lipids (Ademiluyi & Obboh, 2015; Ademiluyi et al., 2019; Dabai et al., 1996; Tan et al., 2021). Fibre-, resistant-starch- and microbiome-mediated mechanisms are biologically plausible but presently depend on indirect evidence from the wider legume and cardiovascular literature (Afolabi et al., 2018; Fu et al., 2022; Lu et al., 2022; Xiong et al., 2021).

Table 4: Cardiovascular pathways potentially influenced by Bambara groundnut, with the directness and level of the Bambara-specific evidence.

Cardio-vascular pathway	Bambara-specific evidence	Experi-mental level	Directness of evidence ^a	Main limitation
ACE/RAAS	ACE-inhibitory peptide fractions and hydrolysates (Arise et al., 2017; Mune Mune et al., 2018; Saetang et al., 2025); renin inhibition (Arise et al., 2017); lung ACE activity in diabetic rats fed a fermented condiment (Ademiluyi & Obboh, 2015)	In vitro, in silico; one rodent study	Direct mechanistic	No BP outcome in any species; digestion reduced activity (Mune Mune et al., 2018)
Lipid metabolism	Exaggerated hyper-cholesterol-aemia (Dabai et al., 1996) versus improved cholesterol or lipid profiles (Ademiluyi & Obboh, 2015; Ademiluyi et al., 2019; Tan et al., 2021) in rats	Animal (rodent)	Direct physio-logical; inconsistent	Co-formulation, fermentation and model differences; no human trial
Oxidative stress and inflammation	ORAC, FRAP, DPPH and superoxide scavenging and lipoxygenase inhibition (Adedayo et al., 2021; Chinnapun & Sakorn, 2022; Oyeyinka et al., 2021); lower liver MDA in rats fed fermented condiments (Ademiluyi et al., 2019)	In vitro (mainly); one rodent study	Direct mechanistic	Physiological relevance of assays and extract concentrations unknown

Glycaemic response	Resistant and digestible starch, and effects of germination and hydrothermal treatment (Afolabi et al., 2018; Chinma et al., 2023); DPP-IV inhibition (Mune Mune et al., 2018; Saetang et al., 2025)	In vitro; indirect human data	Mainly indirect	No Bambara-specific human trial; glycaemia is a risk pathway
Gut-heart axis	None specific; fibre and resistant-starch fermentation inferred from general microbiome research (Lu et al., 2022; Witkowski et al., 2020)	Hypothesis	Indirect	No human Bambara-specific data

^aDefinitions are given in Section 2.5. ACE, angiotensin-converting enzyme; BP, blood pressure; DPP-IV, dipeptidyl peptidase-IV; DPPH, 1,1-diphenyl-2-picrylhydrazyl; FRAP, ferric reducing antioxidant power; MDA, malondialdehyde; ORAC, oxygen radical absorbance capacity; RAAS, renin-angiotensin-aldosterone system

4.0 Discussion

4.1 Translational limitations of the current evidence base

Four limitations apply across all of the pathways reviewed above. They are stated here once, and the pathway sections refer to them only where a limitation specific to that pathway applies.

In vitro and in silico evidence. Enzyme inhibition, radical scavenging and docking scores identify candidate mechanisms in simplified systems. They are not clinical evidence, and the values obtained depend on assay design and conditions (Huang et al., 2005; Pinzi & Rastelli, 2019).

Exposure. Concentrations of extracts, isolated compounds or peptides used in assays may not reflect the exposure achievable in plasma or tissue after normal consumption. Polyphenols are extensively metabolized and circulate at low concentrations, largely as conjugated metabolites (Manach et al., 2005). ACE-inhibitory peptides must remain active during digestion and cross the intestinal barrier, and in vitro ACE inhibition does not always predict an antihypertensive effect in vivo (Vermeirssen et al., 2004). Simulated gastrointestinal digestion significantly reduced the ACE- and DPP-IV-inhibitory activity of Bambara groundnut hydrolysates (Mune Mune et al., 2018).

Animal-to-human translation. Findings from animal models do not always predict human responses (van der Worp et al., 2010). The Bambara groundnut rodent studies used severe

hypercholesterolaemic or diabetic models, high or unreported inclusion levels and short durations, and several did not report numerical outcomes in the text examined (Table 3).

Extrapolation from other legumes. Evidence from other legumes, or from fibre, resistant-starch and microbiome research, cannot be assumed to apply to Bambara groundnut, whose composition and preparation differ. Even for legumes as a category, a meta-analysis of randomized trials found no significant overall effect on BP (Reyneke et al., 2023). Limitations of individual studies, such as small groups, single-sex cohorts, incomplete statistical reporting, co-formulation and non-standardized preparations, are listed in Tables 2 and 3.

4.2 Contradictory animal evidence

The rodent studies do not agree, and the disagreement is informative. Dabai et al. (1996) reported that a Bambara groundnut diet exaggerated hypercholesterolaemia, whereas Tan et al. (2021), Ademiluyi and Oboh (2015) and Ademiluyi et al. (2019) reported improved cholesterol or lipid profiles with Bambara-containing preparations. The inconsistency between animal studies indicates that the cardiovascular effects of Bambara groundnut cannot be interpreted independently of dietary formulation, dose, processing and experimental context. Table 3 shows which of these variables are documented. The cholesterol challenge differed: Dabai et al. (1996) used a severe, cholate-containing semi-purified diet, whereas

Tan et al. (2021) used a high-cholesterol diet of (2015, 2019) studies used streptozotocin-unreported composition and the Ademiluyi et al. induced diabetes or 1% dietary cholesterol.

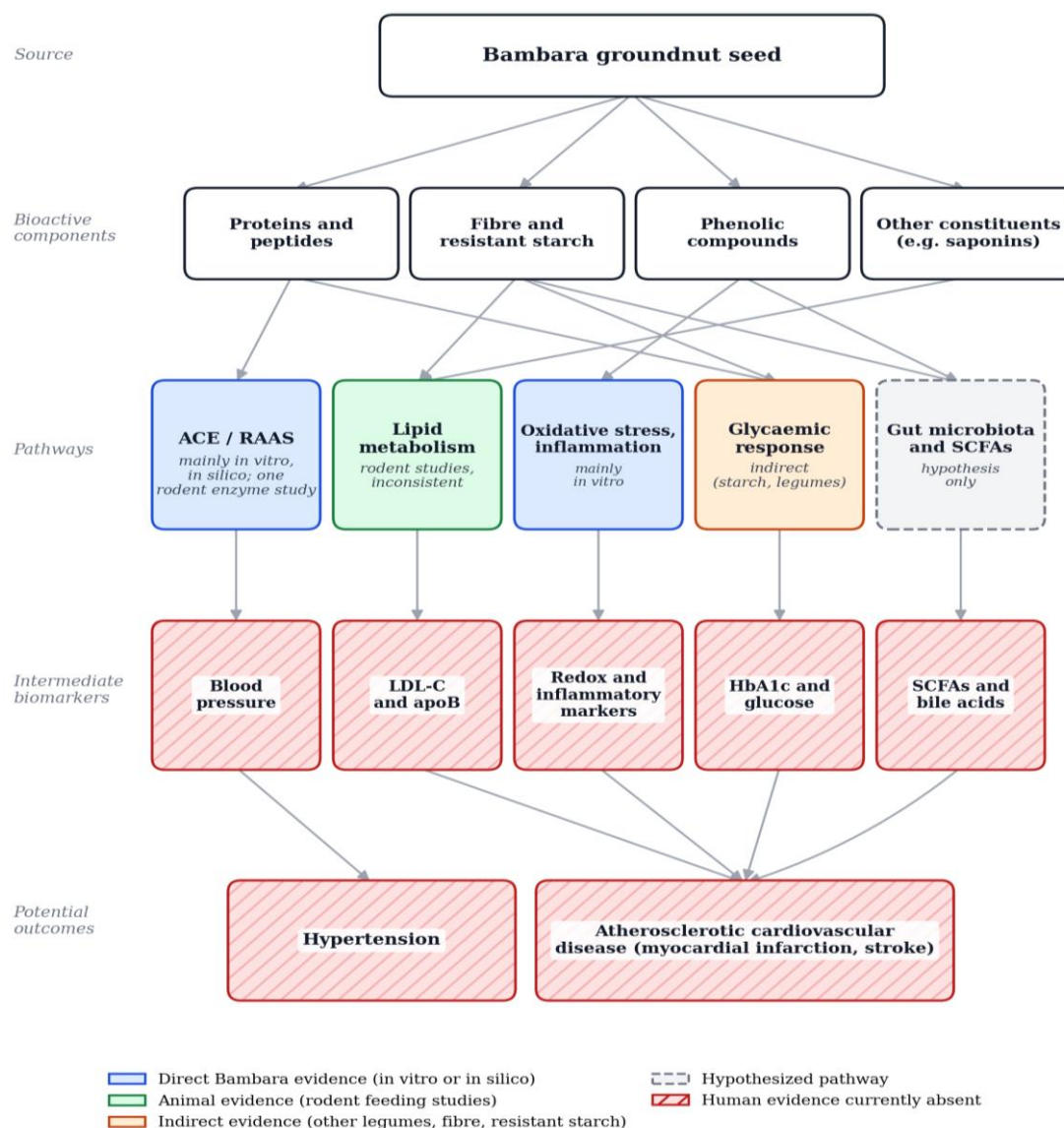


Figure 1: Conceptual evidence map linking Bambara groundnut to cardiovascular outcomes. Pathway boxes are coloured by the predominant Bambara-specific evidence (blue, in vitro or in silico; green, animal; orange, indirect evidence from other legumes; grey dashed, hypothesis only). Hatched boxes indicate that no human evidence linking Bambara groundnut intake to the biomarker or outcome was identified. ACE, angiotensin-converting enzyme; apoB, apolipoprotein B; HbA1c, glycated haemoglobin; LDL-C, low-density lipoprotein cholesterol; RAAS, renin-angiotensin-aldosterone system; SCFAs, short-chain fatty acids.

The Bambara groundnut dose differed: legumes replaced 330 g/kg of the diet in Dabai et al. (1996), compared with 16% condiment in Ademiluyi et al. (2019) and a soy-dominated drink mix in Tan et al. The form of the material differed: cooked, dehulled powder co-formulated with soy in Tan et al. (2021), and fermented condiments tested alongside locust bean and soybean in the Ademiluyi et al. (2015, 2019) studies. Feeding duration ranged from 14

days to 10 weeks including induction, and the animals differed in strain (Sprague-Dawley or Wistar) and, where reported, in sex (female in Tan et al. (2021), male in the Ademiluyi et al. (2015, 2019) studies).

Several details remain unknown from the text that was accessible: the form of Bambara groundnut and the sex of the animals in Dabai et al. (1996), the composition of the high-cholesterol diet and the daily intake in Tan et al.

(2021), the Bambara-specific effect within the pooled condiment groups in the Ademiluyi et al. (2019) studies, and the numerical effect sizes in every study. Because the studies differ in several respects at once, the discrepancy cannot be assigned to any single variable. Processing (fermentation, cooking, dehulling), dietary matrix, model severity and co-ingredients are candidate explanations that should be tested directly, for example by comparing raw, cooked and fermented Bambara groundnut at matched inclusion levels within one model, with legume-matched and soy-matched controls. Until such comparisons exist, the animal evidence should be regarded as inconsistent rather than as demonstrating a lipid-lowering effect of Bambara groundnut.

4.3 Integrated cardiovascular pathway

The pathways summarized in Figure 1 should not be assumed to be additive. The supporting studies used different preparations (protein hydrolysates, extracts, isolated compounds, flours and fermented condiments), different doses and different experimental systems, so strong evidence for one pathway does not strengthen weaker evidence for another, and biological plausibility across several pathways is not equivalent to demonstrated clinical benefit. Bambara-specific evidence is confined to assay-level mechanisms and to inconsistent rodent lipid data, whereas the links from resistant starch and fibre to glycaemic control, from SCFAs to lipid metabolism, and from these to cardiovascular events rest on indirect evidence from other foods and populations. Intermediate biomarkers and cardiovascular outcomes have not been measured in humans who consumed Bambara groundnut. Figure 1 is therefore a map for prioritizing trials, not evidence that any of these pathways operates in people who eat Bambara groundnut.

4.4 Critical evidence gaps and research priorities

The principal research gap is the absence, in the sources searched, of a controlled human intervention study in which a defined Bambara groundnut preparation was compared with an

appropriate control using prespecified cardiovascular endpoints. Table 5 organizes the research priorities by the level of evidence that each would add.

Future randomized controlled trials of sufficient duration should evaluate standardized Bambara groundnut preparations in adults with elevated LDL-C (Grundy et al., 2019), elevated BP or untreated hypertension (McEvoy et al., 2024) or clustered metabolic risk, compared with an appropriate control food. The duration should be justified by the expected time course of the primary endpoint and by comparable legume trials, which have ranged from 4 to 52 weeks for BP outcomes (Reyneke et al., 2023). Trials should include a sample-size calculation based on the primary endpoint, standardization and reporting of the dose and preparation, a comparator chosen to isolate the contribution of Bambara groundnut, assessment of dietary adherence, documentation of baseline cardiovascular risk and medication use, monitoring of adverse events, prospective trial registration and predefined primary and secondary outcomes. Primary outcomes should include LDL-C and systolic BP; secondary outcomes could include apoB, non-HDL-C, triglycerides, diastolic BP, flow-mediated dilation (Thijssen et al., 2019) and CRP (Ridker, 2016). Exposure and background diet should be controlled, and reporting should follow the CONSORT 2025 statement (Hopewell et al., 2025).

Peptide studies should progress from docking to gastrointestinal digestion and pharmacokinetics, including synthesis and individual testing of candidate peptides such as those predicted by Saetang et al. (2025); lipid studies should measure apoB and bile acids; and microbiome studies should assess SCFAs, bile acids, inflammation, lipids and BP in the same participants. Controlled animal experiments that compare raw, cooked and fermented Bambara groundnut at matched inclusion levels against legume-matched controls would also help to resolve the discordant lipid findings (Section

4.2). These priorities are intended to close the principal evidence gaps identified by the review.

Table 5. Research priorities for establishing the cardiovascular relevance of Bambara groundnut.

Priority	Focus	Key design features and outcomes
1	Human intervention studies	Standardized Bambara groundnut preparation; defined dose; appropriate control; LDL-C and systolic BP as major outcomes; preregistered, adequately powered design reported to CONSORT 2025 standards (Hopewell et al., 2025)
2	Bioavailability	Gastrointestinal digestion; absorption; plasma metabolites; peptide stability, including synthesis and testing of predicted peptides (Manach et al., 2005; Vermeirssen et al., 2004)
3	Mechanistic validation	Endothelial function (Thijssen et al., 2019); inflammatory biomarkers; oxidative stress markers; bile acids; apoB
4	Gut-heart pathway	Microbiome sequencing; SCFAs; bile acids; inflammatory and cardio-vascular biomarkers in the same participants
Supporting	Controlled animal studies	Raw, cooked and fermented Bambara groundnut at matched inclusion levels with legume-matched controls, to resolve the discordant lipid findings

4.5 Limitations of this review

This review is a focused narrative synthesis. The search was not exhaustive, screening was done by a single reviewer, only English-language journal articles were considered, no formal risk-of-bias tool was applied, and the classification of evidence is qualitative. Stage-wise record counts were not generated, so the flow of records cannot be reproduced exactly, although the sources, dates, search structure and eligibility criteria are reported. During the supplementary search, six further rodent studies of Bambara-containing diets and one small human study of glycaemic responses to Bambara-based meals were noted in regional journals and repositories, but their full methods, outcomes or bibliographic details could not be verified from the accessible text, so they were not synthesized; they should be evaluated in future updates. The supplementary search also identified two rodent studies that were absent from the original synthesis, which shows that the evidence base can be incompletely captured by a focused search. The statement that no human randomized controlled trial exists therefore applies to the databases and sources searched and should be revisited as new

studies appear. Numerical effect sizes could not be extracted for several rodent studies because they were not reported in the abstracts or open-access text examined.

4.6 Conclusion

Current evidence supports several biologically plausible cardiovascular pathways for Bambara groundnut, particularly ACE inhibition, antioxidant activity and preliminary, inconsistent lipid findings in rodents. However, these findings remain predominantly preclinical, and the available evidence does not establish cardiovascular efficacy in humans. The reviewed evidence supports a cardiovascular-specific framework for investigating Bambara groundnut as a potential cardioprotective food, in which mechanistic findings are distinguished from translational evidence and the evidence needed to establish cardiovascular relevance is defined. Standardized preparations, adequately powered randomized controlled trials and validated cardiovascular endpoints are therefore required before clinically meaningful health claims can be established.

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Author's contributions

Babatunde Joshua conceived the review, conducted the literature search, synthesized the evidence, and prepared and critically revised the manuscript.

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The author used ChatGPT as a tool for language editing, manuscript organization and formatting support. The author remains responsible for the accuracy, originality, interpretation, citations and conclusions presented in this manuscript, and the references and factual statements were checked against publisher, PubMed or repository records during revision.

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