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Cocoa's potential as functional food for diabetes glucose management

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ABSTRAK

Latar Belakang: *Diabetes mellitus (DM) merupakan gangguan metabolik yang ditandai dengan hiperglikemia kronis akibat gangguan sekresi atau fungsi insulin. Manajemen diabetes saat ini masih bergantung pada terapi obat dan perubahan gaya hidup yang sering kali sulit diterapkan secara konsisten, sehingga diperlukan alternatif yang lebih efektif, salah satunya adalah pangan fungsional seperti kakao yang mengandung berbagai senyawa bioaktif yang dapat berperan dalam regulasi glukosa darah.*

Tujuan: *Literatur ini bertujuan untuk mengeksplorasi potensi kakao sebagai pangan fungsional dalam pengelolaan glukosa darah pada penderita diabetes berdasarkan bukti ilmiah yang ada.*

Metode: *Studi ini merupakan narrative review yang dilakukan dengan menelusuri basis data Web of Science, Scopus, dan PubMed dalam rentang tahun 2015–2025. Artikel yang dianalisis uji klinis pada manusia dan meta-analisis terkait konsumsi kakao dan efeknya terhadap parameter diabetes.*

Hasil: *Studi in vivo menunjukkan bahwa diet kaya flavanol kakao dapat meningkatkan sensitivitas insulin, mengurangi kadar HbA1c, dan melindungi sel endotel serta sel pankreas dari stres oksidatif. Meta-analisis uji klinis menunjukkan bahwa suplementasi flavanol kakao (200-600 mg/hari) secara signifikan mengurangi HOMA-IR, trigliserida, dan peradangan. Studi observasional juga menunjukkan bahwa konsumsi cokelat dalam jumlah moderat dapat mengurangi risiko diabetes tipe 2.*

Kesimpulan: *Kakao memiliki potensi untuk berfungsi sebagai makanan fungsional dalam manajemen glukosa darah melalui peningkatan sensitivitas insulin, efek antioksidan, dan modulasi mikrobiota usus. Namun, penelitian klinis jangka panjang yang lebih besar masih diperlukan untuk menentukan dosis optimal dan kemanjuran jangka panjang dari konsumsi kakao dalam pencegahan dan manajemen diabetes.*

KATA KUNCI: *diabetes mellitus; kakao; manajemen glukosa darah; pangan fungsional; senyawa bioaktif*

ABSTRACT

Background: *Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia due to impaired insulin secretion or function, and its management relies heavily on drug therapy and lifestyle modifications, which are often challenging to maintain consistently. Therefore, more effective alternatives, such as functional foods like cocoa, which contain various bioactive compounds that may play a role in blood glucose regulation, are needed.*

Objectives: *This literature review aims to explore the potential of cocoa as a functional food for blood glucose management in diabetic patients based on existing scientific evidence.*

Methods: *This study is a narrative literature review conducted by searching the Web of Science, Scopus, and PubMed databases within the period of 2015–2025. The analyzed articles included clinical trials in humans and meta-analyses related to cocoa consumption and its effects on diabetes-related parameters.*

Results: *In vivo studies show that a flavanol-rich cocoa diet improves insulin sensitivity, reduces HbA1c levels, and protects endothelial and pancreatic cells from oxidative stress. Meta-analyses of clinical trials indicate that cocoa flavanol supplementation (200-600 mg/day) significantly reduces HOMA-IR, triglycerides, and inflammation. Observational studies also suggest that moderate chocolate consumption may reduce the risk of type 2 diabetes.*

Conclusions: *Cocoa has the potential to serve as a functional food for blood glucose management through improved insulin sensitivity, antioxidant effects, and gut microbiota modulation. However, further large-scale clinical trials are needed to determine the optimal dosage and long-term efficacy of cocoa in diabetes prevention and management.*

KEYWORDS*:* *bioactive compounds; blood glucose management; cocoa; diabetes mellitus; functional food*

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INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia due to impaired insulin secretion or function (1). This disease falls into the category of serious non-communicable diseases, with complications that can have a broad impact on health, including heart disease, hypertension, stroke, kidney failure, and even amputations due to diabetic wounds (2). According to data from the International Diabetes Federation (IDF) in 2019, approximately 463 million people, or 9.3% of the global population aged 20-79, had a history of DM, with Indonesia ranking seventh among countries with the highest number of DM cases (3). The increasing prevalence of DM in Indonesia continues, rising from 6.9% in 2013 to 8.5% in 2018, and further increasing to 11.7% in 2023, according to the Indonesian Health Survey (5). This trend indicates that DM remains a significant public health challenge, mainly because its management often relies on medication therapy and lifestyle changes that are difficult to implement consistently (6). Therefore, alternative interventions that are more acceptable to the public are needed, one of which is dietary approaches using food ingredients with natural hypoglycemic effects (7).

One natural ingredient that has gained attention in this context is cocoa (Theobroma cacao L.), which has long been recognized as a high-value agricultural commodity in the global food and beverage industry and is also classified as a functional food. (8). Besides its significant economic value, cocoa contains various bioactive compounds with potential for DM management. Some of the main components in cocoa that positively affect glucose metabolism include polyphenols, methylxanthines (particularly theobromine and caffeine), dietary fiber, and bioactive peptides. 10). Polyphenols in cocoa, such as flavonoids and proanthocyanidins, are known to enhance insulin sensitivity, reduce insulin resistance, and exhibit anti-inflammatory and antioxidant effects that help mitigate oxidative stress, which contributes to DM complications (11). Additionally, methylxanthines like theobromine have the potential to enhance energy metabolism and regulate blood sugar levels through their effects on the central nervous system and lipid metabolism (12). Dietary fiber in cocoa also plays a role in slowing glucose absorption in the digestive tract, thereby helping control postprandial blood sugar spikes (13). Furthermore, bioactive peptides produced during cocoa fermentation and processing have been reported to exhibit α-glucosidase enzyme inhibition activity, which helps lower blood sugar levels by preventing carbohydrate breakdown into glucose in the intestines (14).

Various studies have shown that cocoa powder consumption can significantly reduce fasting blood sugar levels in animal models with diabetes (11). This effect is attributed to the synergy between polyphenols, methylxanthines, dietary fiber, and bioactive peptides in optimizing glucose regulation and metabolic functions (12). Although animal studies indicate promising potential, the present review prioritizes clinical and meta-analytic findings in humans to explore the practical applications of cocoa as a functional food for diabetes management (10). Therefore, this literature review aims to explore the potential of cocoa as a functional food for managing blood glucose levels in DM patients by reviewing scientific evidence on the antidiabetic effects of various bioactive components in cocoa.

MATERIALS AND METHODS

This study is a narrative literature review that explores the potential role of cocoa (Theobroma cacao L.) as a functional food in managing blood glucose levels in individuals with diabetes. A literature search strategy was developed to identify relevant studies, using the PICO framework (Population, Intervention, Comparison, and Outcome), as outlined below:

a. Population: Individuals with type 2 diabetes, prediabetes, metabolic syndrome, insulin resistance, healthy individuals, or animal models of diabetes.
b. Intervention: Consumption of pure cocoa or cocoa-derived products with minimal or no added sugar, such as cocoa powder, dark chocolate (≥70% cocoa), or standardized cocoa extract.
c. Comparison: Individuals or animals not consuming cocoa or receiving alternative dietary interventions.
d. Outcome: Diabetes-related outcomes, with a primary focus on blood glucose regulation, insulin sensitivity, and insulin resistance.

The literature search was conducted across three major electronic databases: Web of Science, Scopus, and PubMed, focusing on publications from 2015 to 2025. The search terms were explicitly defined and consistently applied across the databases to ensure reproducibility. The terms used in the search were: "cocoa" AND ("functional food" OR "nutraceutical") AND "diabetes" AND "blood glucose". These search terms ensured systematic retrieval of relevant studies, and others can reproduce the results following the same search criteria.

a. Inclusion criteria: Peer-reviewed articles that evaluated cocoa interventions in relation to blood glucose control, including studies in both humans and animal models. Eligible studies primarily consisted of randomized controlled trials (RCTs), prospective cohorts, or meta-analyses reporting quantitative outcomes related to diabetes.
b. Exclusion criteria: Editorials, studies lacking a control group, and those without quantitative data on glucose-related outcomes.

As this review was conducted using a narrative approach, rather than a registered systematic review (e.g., PROSPERO), a formal risk of bias assessment and PRISMA checklist were not applied. However, rigorous steps were taken to ensure transparency and reproducibility throughout the review process. Covidence software was employed to manage study screening and data extraction efficiently, following predefined eligibility criteria. To ensure traceability between extracted data and synthesized findings, a comprehensive data extraction table is presented in Appendix 1, while the study selection process is illustrated in **Figure 1**.

RESULTS AND DISCUSSIONS

Cocoa (Theobroma cacao L.) is a tropical plant native to South America and has been widely cultivated in various tropical regions, including Africa, Southeast Asia, and Latin America (15). This plant belongs to the Malvaceae family and is known as the primary source of cocoa beans, which serve as the main ingredient in the production of chocolate, beverages, and various other food products (16). Cocoa beans are rich in bioactive compounds such as flavonols, polyphenols, theobromine, and methylxanthines, which provide various health benefits, particularly in blood glucose regulation and the prevention of metabolic diseases (17).

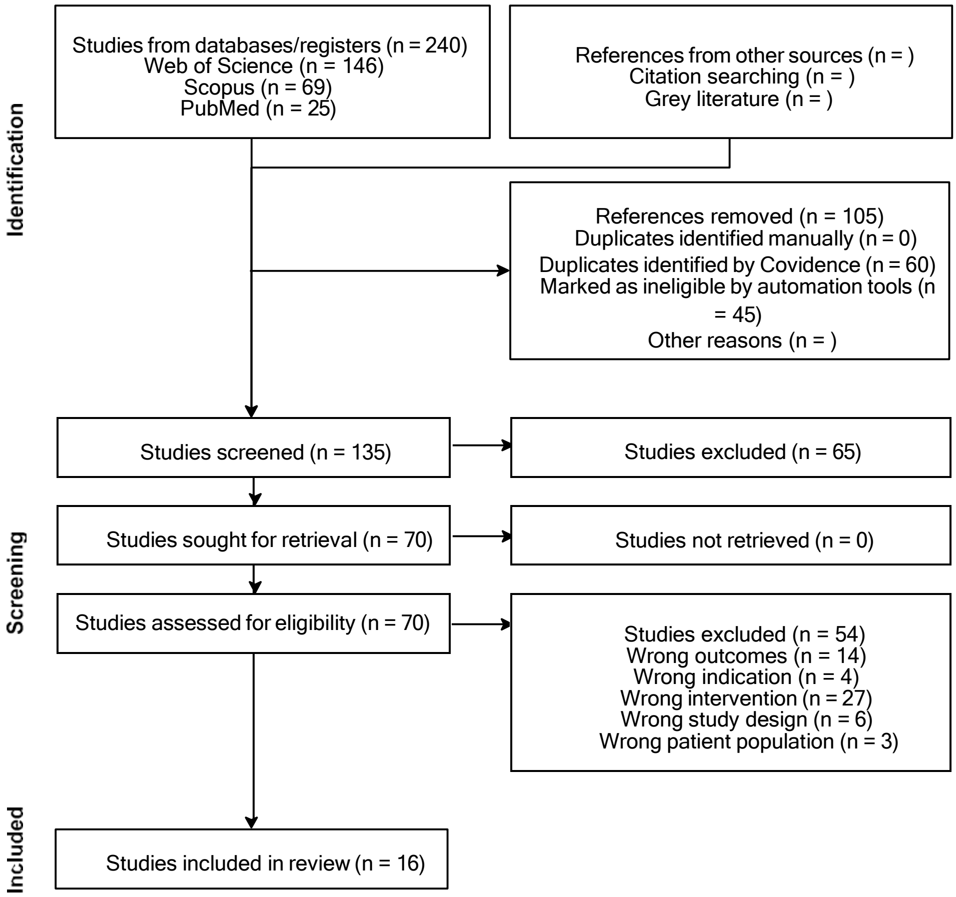

Figure 1. Flow Diagram of Study Selection

Epidemiological studies have shown that moderate cocoa consumption can reduce the risk of type 2 diabetes. Several clinical trials have revealed that cocoa can enhance insulin sensitivity and reduce inflammatory biomarkers, contributing to improved glucose metabolism (12). The antidiabetic potential of cocoa can be seen in **Table 1**.

Scientific research has shown that cocoa and its derivatives have a significant impact on diabetes. The various findings from the research table above explore the effects of cocoa flavanols on glucose metabolism, insulin sensitivity, and vascular function. These studies include meta-analyses and clinical trials, each contributing to a deeper understanding of how cocoa may serve as a beneficial adjunct in managing diabetes.

Meta-Analyses and Prospective Studies in Humans

The effects of cocoa consumption on glucose regulation and metabolic health have been widely explored through meta-analyses and large-scale prospective studies. A meta-analysis of 19 randomized controlled trials (RCTs) reported that cocoa flavanol intake ranging from 166-2110 mg/day significantly reduced HOMA-IR, triglycerides, and C-reactive protein (CRP), with optimal effects observed at doses between 200-600 mg/day (18). Similarly, another meta-analysis of 31 RCTs found significant improvements in fasting glucose, low-density lipoprotein (LDL), total cholesterol, and both systolic and diastolic blood pressure following cocoa or dark chocolate intake (19). These findings are further supported

Table 1. Antidiabetic role of cocoa

Author	Interventions	Study Types	Subjects	Doses	Findings	P-values
Racine et al. (2022)	Cocoa Flavanol Extract	Pilot study, in vivo experiment	ob/ob and WT rats	0.8% cocoa flavanol extract 65 mg/kg/day	In females, reduced fasting hyperglycemia, and in males, improved hyperinsulinemia.	p<0.05 (sig.)
Arisi et al. (2024)	Cocoa extract or ≥70% dark chocolate	Systematic Review & Meta-analysis (31 RCTs)	1986 adults	166-1050 mg/day flavanols or equivalent cocoa	Reduced fasting glucose, LDL, total cholesterol, SBP, and DBP.	p<0.05 (sig.)
Maskarinec et al. (2019)	Chocolate candy intake	Prospective cohort (MEC)	151,691 multiethnic adults (8,487 T2D cases)	≥4 times/week vs <1/month	High frequency chocolate intake associated with 19% lower T2D risk	p<0.0002 (sig.)
Rynarzewski et al. (2019)	Flavanol-rich cocoa (2.5 g) + meal	RCT, double-blind, crossover	12 T2DM patients with obesity & hypertension	2.5 g cocoa with diabetic-suitable meal	No significant effect on glucose, insulin, HOMA-IR, lipids, or BP vs placebo	p>0.05 (not sig.)
Lin et al. (2016)	Cocoa Flavanols from Various Sources	Meta-analysis of 19 RCTs	1131 participants	166-2110 mg flavanols/day	Lowered HOMA-IR, triglycerides, and CRP.	p<0.001 (sig.)
Sesso et al. (2022)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	21,442 adults	500 mg cocoa flavanol per day	27% reduction in CVD-related mortality.	p<0.11 (not sig.)
Simpson et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	32 premenopausal women	2 servings/day	Improvement in HOMA-IR or insulin-mediated glucose.	p<0.07 (not sig.)
Leyva-Soto et al. (2018)	70% Dark Chocolate vs. Milk Chocolate	RCT, double-blind, placebo-controlled	84 individuals with metabolic risk	2 g dark chocolate/day, 6 months	Reduced fasting glucose, HbA1c, HOMA-IR, LDL.	p<0.05 (sig.)
Davis et al. (2020)	Flavanol-rich Cocoa Powder (Beverage)	RCT	18 individuals with T2DM and obesity	20 g cocoa powder	Reduced VLDL, increased HDL.	p<0.05 (sig.)
Basu et al. (2015)	Chocolate Beverage	RCT	18 individuals with T2DM	960 mg total polyphenols	Increased HDL cholesterol and insulin; reduced large artery elasticity	p<0.001 (sig.)

Author	Interventions	Study Types	Subjects	Doses	Findings	P-values
Dicks et al. (2018)	Flavanol-rich cocoa powder (2.5 g)	RCT, double-blind, placebo-controlled	42 patients with T2DM and hypertension	2.5 g/day for 12 weeks	No significant effect on BP, glucose, HbA1c, insulin, HOMA-IR, or lipid profiles	p>0.05 (not sig.)
Li et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	18,381 adults without T2D	500 mg/day cocoa flavanols (80 mg epicatechin), median 3.5 years	No significant reduction in T2D incidence compared to placebo	p=0.58 (not sig.)
Aris et al. (2025)	Cocoa-flavored Soy Powder Drink	In vitro and clinical	12 (glycemic test), 30 (satiety test)	250 mL drink	Low glycemic index (iAUC).	p<0.05 (sig.)
Yuan et al. (2017)	Chocolate Consumption in Diet	Meta-analysis	508,705 participants	Max 6 servings/week	Reduced risk of diabetes, CHD, and stroke.	p<0.001 (sig.)
Matsumoto et al. (2015)	Chocolate Consumption in Diet	Prospective study	18,235 men without diabetes	≥2 servings/week	Reduced diabetes risk.	p<0.047 (sig.)
Baker et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	2,262 older adults (60% women, 73 y/o avg)	500 mg/day cocoa flavanols, 3 years	No significant benefit on cognition, including in subgroup with CVD risk (T2DM-related)	p=0.28 (not sig.)

by prospective cohort studies. For example, chocolate consumption of ≥4 times per week was associated with a 19% lower risk of type 2 diabetes (T2DM) in the Multiethnic Cohort Study (20). In addition, a meta-analysis involving over 500,000 participants demonstrated that consuming up to six servings of chocolate per week was associated with reduced risks of T2DM, coronary heart disease (CHD), and stroke (21). Another study reported a significantly reduced risk of diabetes among men consuming chocolate ≥2 servings per week. Collectively, these studies highlight the long-term preventive potential of regular cocoa intake in reducing the risk of metabolic and cardiovascular diseases.

Clinical Trials in Humans

Clinical trials have reported variable outcomes regarding the metabolic effects of cocoa consumption. In a double-blind RCT, daily intake of 2 g of 70% dark chocolate for six months significantly reduced fasting glucose, HbA1c, HOMA-IR, LDL, and triglycerides in individuals with metabolic risk (22). Additional studies demonstrated that cocoa flavanol-rich powder beverages improved HDL levels, reduced VLDL, and enhanced insulin sensitivity in individuals with type 2 diabetes (16) A cocoa-flavored soy-based drink with a low glycemic index was also shown to lower postprandial glycemia and increase satiety (19). However, several trials using lower doses (such as 2.5 g/day), reported no significant effects on glucose, insulin, HOMA-IR, or lipid parameters, particularly in patients on stable pharmacological treatments (25; 26). Moreover, large-scale randomized controlled trials such as the COSMOS study did not find significant reductions in the incidence of type 2 diabetes or total cardiovascular events with cocoa extract supplementation, although one analysis noted a non-significant 27% reduction in CVD mortality (27).

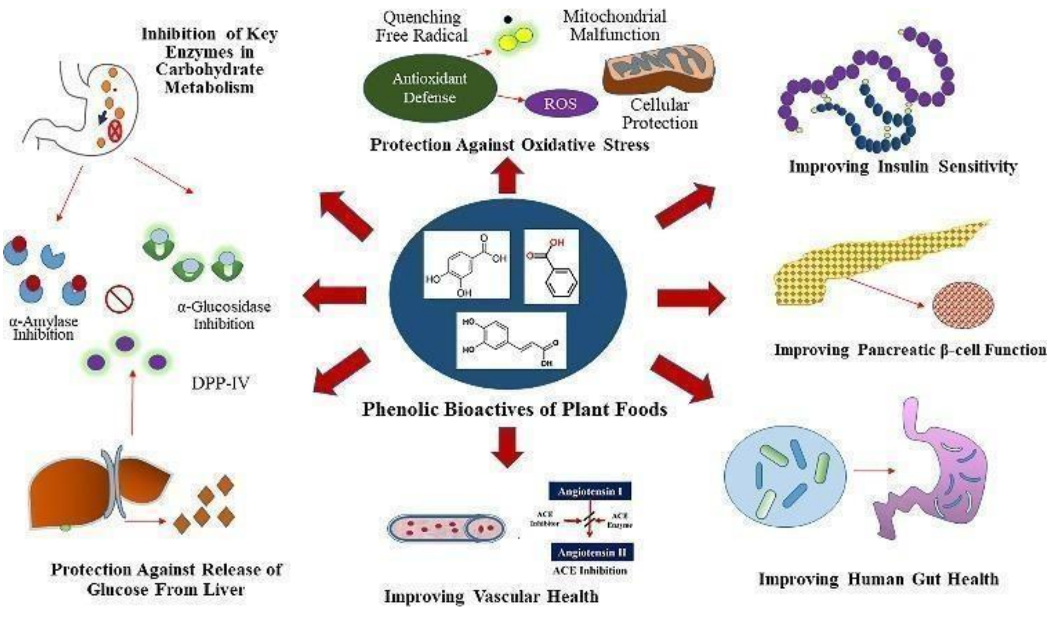

Figure 2. Bioactives Cocoa for Glycemic Control

Cocoa as an antidiabetic agent

Cocoa flavanols are plant-derived bioactive compounds widely recognized for their anti-hyperglycemic properties, making them promising functional ingredients in the management of T2DM. T2DM is characterized by insulin resistance, where body cells become less responsive to insulin, leading to impaired glucose uptake. Cocoa flavanols help address this by enhancing the expression and translocation of GLUT4, a key glucose transporter in skeletal muscle cells, thereby promoting glucose uptake and reducing blood glucose levels. They also activate AMPK signaling, which further facilitates glucose entry into cells independently of insulin (26).

Beyond this, cocoa phenolics support glycemic control through additional mechanisms. These include inhibiting digestive enzymes such as α-amylase and α-glucosidase to slow carbohydrate breakdown, reducing hepatic glucose output, improving β-cell function to enhance insulin production, and modulating the efficiency of insulin receptors and glucose transporters. As illustrated in Figure 2, these combined actions work at multiple levels from digestion to cellular glucose utilization, supporting cocoa's role in maintaining glucose homeostasis and mitigating the risk of postprandial glucose spikes (27). Additionally, cocoa flavanols activate AMP-activated protein kinase (AMPK), a central cellular energy sensor that responds to changes in cellular AMP/ATP ratios. AMPK activation promotes translocation of GLUT4 to the plasma membrane independently of insulin signaling, enhancing glucose uptake in skeletal muscle even under insulin-resistant conditions. This kinase also stimulates mitochondrial biogenesis and fatty acid oxidation, contributing to improved metabolic flexibility and reduced lipid-induced insulin resistance. The synergistic activation of AMPK and insulin signaling pathways, including Akt2 (Protein Kinase B) and PKC (Protein Kinase C), amplifies GLUT4 expression and translocation, optimizing glucose clearance from the bloodstream (16).

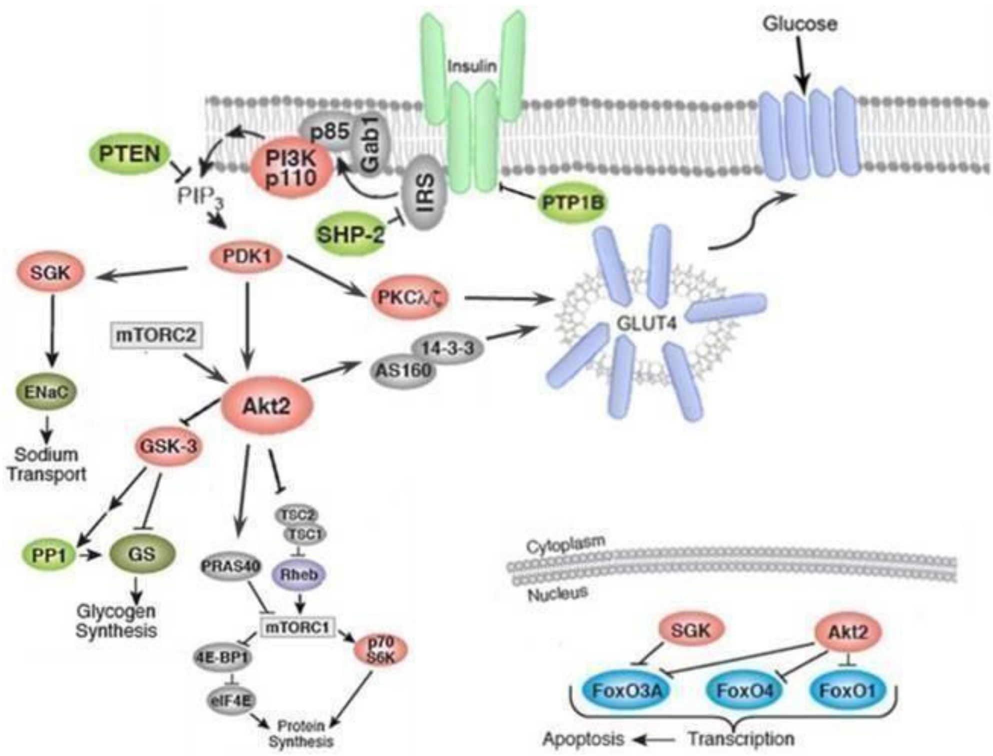

Figure 3. Insulin Signaling Pathway for GLUT4 Translocation

The upregulation of GLUT4 by cocoa flavanols occurs through activating insulin signaling pathways involving key proteins such as Akt2 (Protein Kinase B) and PKC (Protein Kinase C). These pathways promote the translocation of GLUT4 to the cell membrane, as illustrated in Figure 3 of the source article, enhancing glucose uptake by target tissues. This mechanism directly affects blood glucose levels, especially among individuals with impaired glucose metabolism. In addition to improving insulin action, cocoa flavanols exert protective effects on pancreatic β-cells, which are responsible for insulin secretion. Studies have shown that cocoa flavanols can shield β-cells from oxidative damage, one of the primary causes of β-cell dysfunction in diabetes. By preserving β-cell integrity, cocoa helps maintain insulin secretion and overall glucose metabolism (28). Moreover, long-term consumption of cocoa has been associated with reductions in HbA1c levels, a reliable biomarker for long-term glycemic control that reflects average blood glucose over a two- to three-month period (17).

However, not all studies have yielded consistent results. In one study, cocoa flavanol supplementation did not significantly improve HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) or insulin-mediated glucose uptake, with a reported p-value of 0.07 (29). Although this result approaches the threshold of statistical significance, it remains outside the conventional $p < 0.05$ level. This suggests that the metabolic response to cocoa may vary between individuals and may be influenced by factors such as body mass index (BMI), dietary patterns, and comorbidities. Therefore, further research with stricter control of confounding variables is warranted.

Antioxidant and anti-inflammatory effects

Beyond its direct effects on glucose metabolism, cocoa is also well known for its potent antioxidant and anti-inflammatory properties, largely attributed to its flavanol and procyanidin content. Oxidative stress and chronic inflammation are key contributors to the pathogenesis of insulin resistance and the progression of diabetes. In hyperglycemic states, excessive production of reactive oxygen species (ROS) leads to cellular damage, including damage to pancreatic β-cells. Cocoa flavanols have been shown to neutralize ROS and thereby prevent oxidative injury (30). This protective mechanism is particularly important, as β-cells are inherently vulnerable to oxidative stress due to their relatively low levels of endogenous antioxidant enzymes. By reducing oxidative damage in these cells, cocoa supports more stable insulin production and secretion, which is vital for long-term glycemic control (26,18).

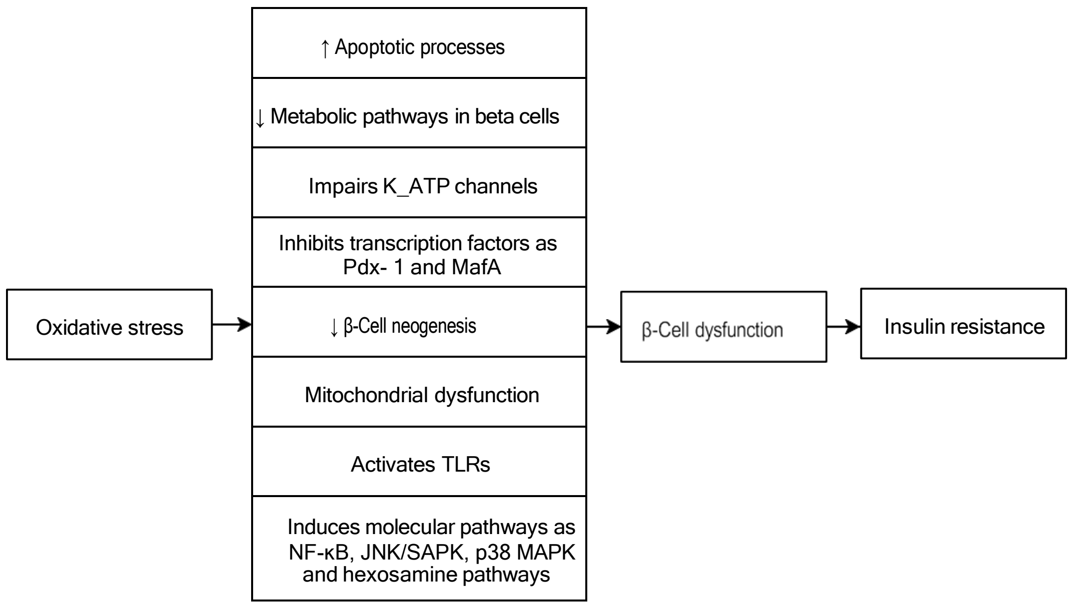

Figure 4. Oxidative Stress and β-Cell Dysfunction

Figure 4 highlights how oxidative stress contributes to β-cell dysfunction and how cocoa exerts its protective role. Furthermore, cocoa flavanols exert anti-inflammatory effects primarily by modulating the NF-κB (nuclear factor kappa-light-chain-enhancer of activated B cells) signaling pathway. NF-κB is a transcription factor pivotal in regulating genes responsible for the inflammatory response. Cocoa flavanols inhibit the activation and nuclear translocation of NF-κB, resulting in downregulation of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and other mediators that contribute to insulin resistance and β-cell dysfunction. By dampening this chronic low-grade inflammation, cocoa helps restore insulin signaling pathways and improve metabolic homeostasis (31). This molecular modulation is a key mechanism linking cocoa consumption to improved insulin sensitivity and protection against diabetes-associated inflammation.

Through this dual mechanism, antioxidant and anti-inflammatory cocoa improves insulin sensitivity and mitigates the metabolic disturbances that lead to hyperglycemia. Furthermore, cocoa contains methylxanthines, including theobromine and caffeine, which contribute to improved metabolic control and insulin responsiveness (31). Cocoa is also rich in phenolic acids such as gallic acid and ferulic acid, which exert neuroprotective and antioxidant effects. These compounds not only safeguard the nervous system but also support glucose homeostasis by attenuating oxidative stress and inflammation associated with diabetes (22).

Despite these promising effects, the evidence is not uniformly consistent across studies. For instance, a 27% reduction in cardiovascular disease (CVD)-related mortality was reported with cocoa flavanol supplementation ($p < 0.11$), yet no significant impact was found on total CVD events (25). While the reduction in mortality suggests potential cardiovascular benefits, the borderline p-value ($p < 0.11$) limits the strength of the conclusion. This inconsistency underscores the need for standardized intervention protocols in future clinical trials to enhance the reliability and reproducibility of findings.

LIMITATIONS OF THE RESEARCH

Although cocoa flavanols have shown promising effects in managing glucose metabolism and improving insulin sensitivity, several limitations must be addressed in future studies: Study Heterogeneity: Variability in cocoa flavanol content (e.g., differences in cocoa bean type, processing methods, and flavanol concentrations) across studies can lead to inconsistent results. Studies used different forms of cocoa (e.g., flavanol-rich extract vs. dark chocolate), which may affect the bioavailability of flavanols and their effectiveness in regulating blood glucose and HbA1c; Confounding Factors: Factors such as lifestyle, dietary habits, and medication use could introduce biases in clinical trials, affecting the generalizability of results. BMI, comorbidities, and physical activity levels can influence the efficacy of cocoa in improving insulin sensitivity and HbA1c levels; Sample Size and Duration: Many studies had small sample sizes and short durations, which limit the reliability of the findings. Larger studies with longer follow-up periods are needed to assess the long-term effects of cocoa flavanols on HbA1c regulation and diabetes management.

CONCLUSION AND RECOMMENDATION

This narrative review highlights the potential role of cocoa flavanols in the management of diabetes mellitus, particularly through their effects on insulin sensitivity, glucose metabolism, and HbA1c reduction. These benefits are mediated by several mechanisms, including antioxidant, anti-inflammatory, and enzyme-modulating properties, which collectively support improved glycemic control. Despite these promising outcomes, the existing body of research still presents some limitations, especially regarding inconsistencies in dosage, formulation, and intervention duration. Based on reviewed evidence, a daily intake of cocoa flavanols in the range of 200-600 mg (particularly around 500 mg/day) may be considered effective and practical for future interventions. Cocoa-based products should be standardized in flavanol content and preferably consumed without excessive added sugar or fat.

Further research is recommended in the form of well-designed, long-term randomized controlled trials that control for confounding lifestyle and dietary factors. Future studies should also explore the potential of cocoa flavanols to prevent or ameliorate diabetes-related complications such as nephropathy and neuropathy, and evaluate the safety of continuous daily consumption. Lastly, developing accessible, acceptable, and palatable cocoa-based functional food products may enhance patient adherence and expand clinical application.

REFERENCES

1. Darenskaya MA, Kolesnikova LI, Kolesnikov SI. Oxidative Stress: Pathogenetic Role in

Diabetes Mellitus and Its Complications and Therapeutic Approaches to Correction. Bull Exp Biol Med. 2021 May;171(2):179-89. https://doi.org/10.1007/s10517-021-05191-7
2. Priyanto A, Juwariah T. Hubungan Self Care Dengan Kestabilan Gula Darah Pasien Diabetes Mellitus Type II. jik. 2021 Dec 15;10(1):74–81. https://doi.org/10.32831/jik.v10i1.376
3. International Diabetes Federation (IDF). IDF Diabetes Atlas Ninth edition 2019. BELGIUM: International Diabetes Federation; 2019.
4. Badan Kebijakan Pembangunan Kesehatan. Survei Kesehatan Indonesia (SKI) tahun 2023 dalam Angka. Jakarta: Kemenkes BKPK; 2023.
5. Riset Kesehatan Dasar (Riskesdas). Jakarta: Kemenkes RI; 2018.
6. Perkumpulan Endokrinologi Indonesia (PERKENI). Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa. Jakarta: PB PERKENI; 2019.
7. Nurhayati N, Marseno DW, Setyabudi FS, Supriyanto S. Pengaruh Steam Blanching terhadap Aktivitas Polifenol Oksidase, Total Polifenol dan Aktivitas Antioksidan Biji Kakao. J Apl Teknol Pang. 2018 Oct 23;7(3). https://doi.org/10.17728/jatp.2314
8. Tobias PA, Downs J, Epaina P, Singh G, Park RF, Edwards RJ, et al. Parental assigned chromosomes for cultivated cacao provides insights into genetic architecture underlying resistance to vascular streak dieback. The Plant Genome. 2024 Dec;17(4):e20524. https://doi.org/10.1002/tpg2.20524
9. Ayustina PM, Rai Suarni NM, Ermayanti NGAM. Potensi Ekstrak Etanol Daun Kelor (Moringa Oleifera) Terhadap Kualitas Spermatozoa dan Hormon Testosteron Tikus Putih Jantan yang Diinduksi Meloxicam. metamorfosa. 2022 Oct 13;9(2):247. https://doi.org/10.24843/metamorfosa.2022.v09.i02.p03
10. Assagaf M, Asur G, Kasuba S. Preferensi Konsumen terhadap Dodol Coklat dari Biji Kakao. PRO. 2022 July 25;1(1):260–70. https://doi.org/10.55180/pro.v1i1.262
11. Ramos S, Martin, MA, Goya L. Effects of Cocoa Antioxidants in Type 2 Diabetes Mellitus. Antioxidants. 2017;6(4). https://doi.org/10.3390/antiox6040084
12. Martin M, Ramos S. Impact of Cocoa Flavanols on Human Health. Food Chem Toxicol. 2021;151:112121. https://doi.org/10.1016/j.fct.2021.112121
13. Restuti ANS, Yulianti A, Nuraini N. Intervensi Bubuk Kakao terhadap Perubahan Kadar Gula Darah Puasa Tikus Sprangue Dawley Diabetes Melitus. Jurnal Riset Kesehatan. 2018 Dec 1;7(2):57–60. https://doi.org/10.31983/jrk.v7i2.3646
14. Barišić V, Icyer NC, Akyil S, Toker OS, Flanjak I, Ačkar Đ. Cocoa based beverages – Composition, nutritional value, processing, quality problems and new perspectives. Trends in Food Science & Technology. 2023 Feb;132:65-75. https://doi.org/10.1016/j.tifs.2022.12.011
15. Fernández-Millán E, Ramos S, Alvarez-Cilleros D, Samino S, Amigó N, Correig X, et al. Urinary Metabolomics Study on the Protective Role of Cocoa in Zucker Diabetic Rats via 1H-NMR-Based Approach. Nutrients. 2022;14(19). https://doi.org/10.3390/nu14194127
16. Davis D, Tallent R, Navalta J, Salazar A, Lyons T, Basu A. Effects of Acute Cocoa Supplementation on Postprandial Apolipoproteins, Lipoprotein Subclasses, and Inflammatory Biomarkers in Adults with Type 2 Diabetes after a High-Fat Meal. Nutrients. 2020;12(7). https://doi.org/10.3390/nu12071902
17. Alvarez-Cilleros D, López-Oliva M, Morales-Cano D, Barreira B, Pérez-Vizcaíno F, Goya L, et al. Dietary Cocoa Prevents Aortic Remodeling and Vascular Oxidative Stress in Diabetic Rats. Molecular Nutrition & Food Research. 2019;63(18). https://doi.org/10.1002/mnfr.201900044
18. Lin X, Zhang I, Li A, Manson J, Sesso H, Wang L, et al. Cocoa Flavanol Intake and Biomarkers for Cardiometabolic Health: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Journal of Nutrition. 2016;146(11):2325-33. https://doi.org/10.3945/jn.116.237644
19. Aris HM, Kasim ZM, Zubairi SI. Antihypertensive, Anti-inflammatory,

Glycaemic, and Satiety Effects of Cocoa-Flavoured Soy-Based Powder Drink Mix Enriched with Bioactive Hydrolysates from Nests of Aerodramus fuciphagus. Food Quality and Safety. 2025 Jan 18;9:fyae044. https://doi.org/10.1093/fqsafe/fyae044

20. Maskarinec G, Jacobs S, Shvetsov Y, Boushey CJ, Setiawan VW, Kolonel LN, et al. Intake of cocoa products and risk of type-2 diabetes: the multiethnic cohort. Eur J Clin Nutr. 2019 May;73(5):671–8. https://doi.org/10.1038/s41430-018-0188-9
21. Yuan S, Li X, Jin Y, Lu J. Chocolate Consumption and Risk of Coronary Heart Disease, Stroke, and Diabetes: A Meta-Analysis of Prospective Studies. Nutrients. 2017;9(7). https://doi.org/10.3390/nu9070688
22. Leyva-Soto A, Chavez-Santoscoy R, Lara-Jacobo L, Chavez-Santoscoy A, Gonzalez-Cobian L. Daily Consumption of Chocolate Rich in Flavonoids Decreases Cellular Genotoxicity and Improves Biochemical Parameters of Lipid and Glucose Metabolism. Molecules. 2018;23(9). https://doi.org/10.3390/molecules23092220
23. Rynarzewski J, Dicks L, Zimmermann BF, Stoffel-Wagner B, Ludwig N, Helfrich HP, et al. Impact of a Usual Serving Size of Flavanol-Rich Cocoa Powder Ingested with a Diabetic-Suitable Meal on Postprandial Cardiometabolic Parameters in Type 2 Diabetics—A Randomized, Placebo-Controlled, Double-Blind Crossover Study. Nutrients. 2019 Feb 16;11(2):417. https://doi.org/10.3390/nu11020417
24. Dicks L, Kirch N, Gronwald D, Wernken K, Zimmermann B, Helfrich H, et al. Regular Intake of a Usual Serving Size of Flavanol-Rich Cocoa Powder Does Not Affect Cardiometabolic Parameters in Stably Treated Patients with Type 2 Diabetes and Hypertension-A Double-Blinded, Randomized, Placebo-Controlled Trial. Nutrients. 2018;10(10). https://doi.org/10.3390/nu10101435
25. Sesso HD, Manson JE, Aragaki AK, Rist PM, Johnson LG, Friedenberg G, et al. Effect of Cocoa Flavanol Supplementation For The Prevention of Cardiovascular Disease Events: The Cocoa Supplement and Multivitamin Outcomes Study (COSMOS) Randomized Clinical Trial. Am J Clin Nutr. 2022;115(6):1490–500. https://doi.org/10.1093/ajcn/nqac055
26. Santos HO, Macedo RC. Cocoa-induced (Theobroma cacao) Effects on Cardiovascular System: HDL Modulation Pathways. Clinical Nutrition Espen. 2018;27(10):10–5. https://doi.org/10.1016/j.clnesp.2018.06.001
27. Racine K, Iglesias-Carres L, Herring J, Ferruzzi M, Kay C, Tessem J, et al. Cocoa Extract Exerts Sex-Specific Anti-Diabetic Effects In An Aggressive Type-2 Diabetes Model: A Pilot Study. Biochemical and Biophysical Research Communications. 2022;626:205–10. https://doi.org/10.1016/j.bbrc.2022.08.018
28. García-Díez E, López-Oliva M, Caro-Vadillo A, Pérez-Vizcaíno F, Pérez-Jiménez J, Ramos S, et al. Supplementation with a Cocoa-Carob Blend, Alone or in Combination with Metformin, Attenuates Diabetic Cardiomyopathy, Cardiac Oxidative Stress and Inflammation in Zucker Diabetic Rats. Antioxidants. 2022;11(2). https://doi.org/10.3390/antiox11020432
29. Simpson E, Mendis B, Dunlop M, Schroeter H, Kwik-Uribe C, Macdonald I. Cocoa Flavanol Supplementation and the Effect on Insulin Resistance in Females Who Are Overweight or Obese: A Randomized, Placebo-Controlled Trial. Nutrients. 2023;15(3). https://doi.org/10.3390/nu15030565
30. Yaribeygi H, Sathyapalan T, Atkin SL, Sahebkar A. Molecular Mechanisms Linking Oxidative Stress and Diabetes Mellitus. Oxidative Medicine and Cellular Longevity. 2020 Mar 9;2020:1-13. https://doi.org/10.1155/2020/8609213
31. Alvarez-Cilleros D, Ramos S, López-Oliva M, Escrivá F, Alvarez C, Fernández-Millán E, et al. Cocoa Diet Modulates Gut Microbiota Composition and Improves Intestinal Health in Zucker Diabetic Rats. Food Research International. 2020;132. https://doi.org/10.1016/j.foodres.2020.109058.

APPENDIX

Appendix 1. Summary of Included Studies on the Antidiabetic Effects of Cocoa

Author	Interventions	Study Types	Subjects	Doses	Findings	P-values
Racine et al. (2022)	Cocoa Flavanol Extract	Pilot study, in vivo experiment	ob/ob and WT rats	0.8% cocoa flavanol extract 65 mg/kg/day	In females, reduced fasting hyperglycemia, and in males, improved hyperinsulinemia.	p<0.05 (sig.)
Arisi et al. (2024)	Cocoa extract or ≥70% dark chocolate	Systematic Review & Meta-analysis (31 RCTs)	1986 adults	166-1050 mg/day flavanols or equivalent cocoa	Reduced fasting glucose, LDL, total cholesterol, SBP, and DBP.	p<0.05 (sig.)
Maskarinec et al. (2019)	Chocolate candy intake	Prospective cohort (MEC)	151,691 multiethnic adults (8,487 T2D cases)	≥4 times/week vs <1/month	High frequency chocolate intake associated with 19% lower T2D risk	p<0.0002 (sig.)
Rynarzewski et al. (2019)	Flavanol-rich cocoa (2.5 g) + meal	RCT, double-blind, crossover	12 T2DM patients with obesity & hypertension	2.5 g cocoa with diabetic-suitable meal	No significant effect on glucose, insulin, HOMA-IR, lipids, or BP vs placebo	p>0.05 (not sig.)
Lin et al. (2016)	Cocoa Flavanols from Various Sources	Meta-analysis of 19 RCTs	1131 participants	166-2110 mg flavanols/day	Lowered HOMA-IR, triglycerides, and CRP.	p<0.001 (sig.)
Sesso et al. (2022)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	21,442 adults	500 mg cocoa flavanol per day	27% reduction in CVD-related mortality.	p<0.11 (not sig.)
Simpson et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	32 premenopausal women	2 servings/day	Improvement in HOMA-IR or insulin-mediated glucose.	p<0.07 (not sig.)
Leyva-Soto et al. (2018)	70% Dark Chocolate vs. Milk Chocolate	RCT, double-blind, placebo-controlled	84 individuals with metabolic risk	2 g dark chocolate/day, 6 months	Reduced fasting glucose, HbA1c, HOMA-IR, LDL.	p<0.05 (sig.)
Davis et al. (2020)	Flavanol-rich Cocoa Powder (Beverage)	RCT	18 individuals with T2DM and obesity	20 g cocoa powder	Reduced VLDL, increased HDL.	p<0.05 (sig.)
Basu et al. (2015)	Chocolate Beverage	RCT	18 individuals with T2DM	960 mg total polyphenols	Increased HDL cholesterol and insulin; reduced large artery elasticity	p<0.001 (sig.)

Author	Interventions	Study Types	Subjects	Doses	Findings	P-values
Dicks et al. (2018)	Flavanol-rich cocoa powder (2.5 g)	RCT, double-blind, placebo-controlled	42 patients with T2DM and hypertension	2.5 g/day for 12 weeks	No significant effect on BP, glucose, HbA1c, insulin, HOMA-IR, or lipid profiles	$p>0.05$ (not sig.)
Li et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	18,381 adults without T2D	500 mg/day cocoa flavanols (80 mg epicatechin), median 3.5 years	No significant reduction in T2D incidence compared to placebo	$p=0.58$ (not sig.)
Aris et al. (2025)	Cocoa-flavored Soy Powder Drink	In vitro and clinical	12 (glycemic test), 30 (satiety test)	250 mL drink	Low glycemic index (iAUC).	$p<0.05$ (sig.)
Yuan et al. (2017)	Chocolate Consumption in Diet	Meta-analysis	508,705 participants	Max 6 servings/week	Reduced risk of diabetes, CHD, and stroke.	$p<0.001$ (sig.)
Matsumoto et al. (2015)	Chocolate Consumption in Diet	Prospective study	18,235 men without diabetes	≥2 servings/week	Reduced diabetes risk.	$p<0.047$ (sig.)
Baker et al. (2023)	Cocoa flavanol supplementation	RCT, double-blind, placebo-controlled	2,262 older adults (60% women, 73 y/o avg)	500 mg/day cocoa flavanols, 3 years	No significant benefit on cognition, including in subgroup with CVD risk (T2DM-related)	$p=0.28$ (not sig.)