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The effect of resistant dextrin on glucose regulation markers in patients with type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials

Mohammad Rudiansyah[1*], Dina Akeel Salman[2], Hardik Doshi[3], Renuka Jyothi S.[4], Debasish Shit[5], Swati Sharma[6] and Mehran Nouri[7,8*]

Abstract

Objectives The increasing prevalence of type 2 diabetes (T2D) necessitates greater efforts to find effective therapeutic agents for this complex condition. This study conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to evaluate the effects of resistant dextrin (RD) supplementation on markers of glucose regulation in patients with T2D.

Methods The databases PubMed, Web of Science, Scopus, and the Cochrane Library were searched from inception to March 20, 2025 aiming to identify RCTs evaluating the effect of RD supplementation on fasting blood sugar (FBS), fasting insulin levels, and glycosylated hemoglobin (HbA1c) in patients with T2D. The meta-analysis was conducted using a random-effects model to calculate weighted mean differences (WMDs) and corresponding 95% confidence intervals (95% CI). The quality of the included RCTs was assessed using the Cochrane risk of bias tool. The outcome data was pooled using Stata software, version 11.2.

Results Four RCTs (260 participants) were included in the systematic review and meta-analysis. Meta-analyses indicated that RD supplementation was associated with a significant reduction in HbA1c levels (WMD: -0.30%; 95% CI: -0.56 to -0.03; $P=0.02$; $I^2=0.0\%$). However, the effect of RD on FBS (WMD: -5.45 mg/dl, 95% CI: -12.38 to 1.93; $P=0.14$; $I^2=55.3\%$) and fasting insulin levels (Hedges' g: -0.26; 95% CI: -0.74 to 0.21; $P=0.28$; $I^2=70.4\%$) was not statistically significant.

Conclusion This systematic review and meta-analysis demonstrated that RD supplementation may effectively lower HbA1c levels in patients with T2D. However, it is crucial to conduct more clinical studies with adequate sample sizes and rigorous methodologies to develop evidence-based treatment guidelines.

Keywords Resistant dextrin, Type 2 diabetes, Systematic review, Meta-analysis

*Correspondence:
Mohammad Rudiansyah
rudiansyah@ulm.ac.id
Mehran Nouri
mehran_nouri71@yahoo.com

Full list of author information is available at the end of the article

Introduction

The number of individuals diagnosed with type 2 diabetes (T2D) has risen alarmingly. Currently, over 500 million people are affected by the disease, and projections suggest that this number could reach 783 million by the year 2045 [1]. This condition can result in several complications, such as cardiovascular disease (CVD), neuropathy, nephropathy, retinopathy, and multiple organ dysfunction or failure [2, 3]. While lifestyle changes, physical activity, and medication are the most effective strategies for preventing and managing T2D, healthcare systems also require additional supportive approaches alongside these established methods [4, 5]. In recent decades, researchers have increasingly focused on herbal medicine and functional foods as alternative options for managing T2D [6–10].

Recent investigations have focused on resistant dextrins (RDs) due to their potential role in diabetes management [11]. RDs are a type of dietary fiber that is derived from starch and resists digestion in the small intestine [12]. Unlike conventional carbohydrates, they pass into the large intestine, where they are fermented by gut microbiota. This fermentation process produces short-chain fatty acids (SCFAs), which have anti-inflammatory properties and are linked to various health benefits, including improved gut health, better lipid profiles, weight reduction, increased satiety, and more effective regulation of blood sugar levels [13–15]. These advantages are particularly important for individuals with metabolic disorders such as obesity, CVD, and T2D [11, 15]. Several clinical trials have investigated the effects of RD on improving glycemic indices in patients with T2D [12, 16–18]. However, the results have been inconsistent. Some studies report significant benefits in blood glucose regulation [16, 18], while others indicate minimal or no impact [12, 17]. The varying outcomes in randomized controlled trials (RCTs) may be attributed to differences in study designs, intervention dosages and durations, as well as the age and sex diversity among participants.

This variability underscores the need for a comprehensive study that can offer clearer insights into the overall clinical effects of RD on glycemic control in patients with T2D. Present systematic review and meta-analysis was conducted to evaluate the efficacy and safety of RD supplementation in the management of T2D. This review focused on its effects on glucose regulation, including fasting blood sugar (FBS), fasting insulin levels, and glycosylated hemoglobin (HbA1c), by identifying all available RCTs.

Methods

This systematic review was conducted following the 2020 version PRISMA (preferred reporting items for systematic reviews and meta-analyses) standards and protocol (Supplementary Table 1) [19].

Search strategy

A comprehensive literature search was conducted to identify relevant studies published in English. Two independent authors (H.D and D.Sh) searched the PubMed, Cochrane Library, Web of Science, and Scopus databases from their inception until March 20, 2025. The following search terms were utilized: (Dextrins OR Indigestible Dextrin OR Resistant Dextrin OR Resistant Maltodextrin OR Nutriose) AND (Diabetes OR Type 2 Diabetes Mellitus OR Hyperglycemia OR T2D). Additionally, a reference search was carried out on pertinent studies to discover further relevant research. A gray literature search was conducted on Google Scholar. A sample of the literature search strategy, PubMed search strategy, developed using a combination of MeSH terms and free texts is presented as a supplementary file (Supplementary Table 2).

Study selection

After removing duplicates using EndNote® software, two authors (H.D and D.Sh) independently reviewed the titles and abstracts of the remaining articles. Articles that did not meet the inclusion criteria were excluded at this stage. Subsequently, the same reviewers conducted a full-text assessment of the remaining articles. Any discrepancies were resolved by a third investigator (M.R). The articles were evaluated using the PICOS framework, which includes participants, interventions, comparisons, outcomes, and study design. Clinical trials were included in this meta-analysis if they met all the following eligibility criteria: Participants: The average age of participants was over 18 years and had T2D; Intervention: The intervention arm involved any dose of RD; Comparison: There was either a placebo group or a suitable comparison group; Outcomes: The primary outcomes were the effects of RD supplementation on plasma levels of FBS, fasting insulin, or HbA1c; Study Design: RCTs were performed using either a parallel or crossover design. Non-randomized studies, reviews, letters, conference abstracts, and observational studies were excluded. Additionally, studies including children, pregnant women, or lactating women were also excluded. Articles with an intervention duration of less than one week were likewise excluded.

Data extraction

The data extraction process was carried out independently by two reviewers (H.D and D.Sh) who utilized a pre-tested extraction sheet. In cases of disagreement between the two reviewers, a third reviewer (M.R) was available to resolve the conflict. The information collected included the following details: the last name of the first author, the year of publication, the study design, the total sample size, the mean age, and sex of the study participants, the mean duration of diabetes, the dosage and

duration of the intervention, the type of control group, and finally, the mean and standard deviations (SDs) of the outcomes being investigated at both baseline and the last follow-up, or the changes observed between baseline and post-intervention.

Quality assessment

The quality of the included trials was evaluated using the Cochrane risk-of-bias assessment tool for RCTs [20]. This tool examines the risk of bias across seven domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessments, incomplete outcome data, selective reporting, and other biases. Based on the reviewers' evaluations of these domains, the risk of bias can be categorized into three levels: "low risk of bias," "unclear concerns," and "high risk of bias." Furthermore, the overall quality of the studies was classified as weak, fair, or good, depending on the number of domains rated as low risk: fewer than 3 domains for weak, 3 domains for fair, and 4 or more domains for good. Two authors independently (H.D and D.Sh) carried out the quality assessment, and in cases of disagreement, they discussed the scores until a consensus was reached.

Evaluation of evidence strength

The certainty of the evidence for each outcome was independently evaluated by two investigators using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework. Any disagreements between the investigators were resolved through discussion. This evaluation focused on several domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias [21]. The quality of the evidence was rated as high, moderate, low and very low.

Statistical analysis

Data were analyzed using Stata version 11.2 software (StataCorp, College Station, Texas, USA). The effect size of each study was calculated based on the means and SD of the outcomes before and after the intervention. These were presented as weighted mean differences (WMD) along with 95% confidence intervals (CI). To calculate the effect size for fasting insulin, Hedges' g was used. This was determined by taking the differences between the mean serum levels of fasting insulin in RD and control groups, divided by the corresponding SD [22]. In cases where only the standard deviations for the baseline and final values were provided, the standard deviation for the net changes was estimated using the Follmann method, applying a correlation coefficient of 0.5 [23]. Due to the different settings in which the selected RCTs were conducted, a random-effects model was utilized to calculate the overall effect from the effect sizes. The I-squared (I^2) index was also calculated to assess the degree of heterogeneity, with a value greater than 50% indicating high heterogeneity [24]. A sensitivity analysis was performed to evaluate potential bias and the robustness of the overall effect estimate by excluding one study at a time. Since the effect size for each outcome was less than 10, we were unable to create funnel plots; thus, the presence of publication bias was examined solely through Egger's regression model [25]. All statistical tests were two-sided, and a P-value of less than 0.05 was considered statistically significant.

Results

Literature search and selection

The process of literature search and screening is displayed in Fig. 1. Initially, a total of 486 articles were retrieved. After removing duplicates, 153 articles were excluded, and 310 articles were found to be irrelevant to the research title and abstract. Of the remaining 23 studies, 19 were excluded during the full-text review stage. Ultimately, four eligible articles were included in this meta-analysis [12, 16–18].

Study characteristics

The characteristics of the included studies are summarized in Table 1. All studies, with one exception [17], used a parallel design. The articles reviewed were published between 2015 and 2022. Two of the studies were conducted in Iran, while the others took place in China and Spain. Notably, two studies focused exclusively on female participants [12, 18], while the remaining studies included both men and women. The average age of participants ranged from 47 to 60 years. The intervention doses of RD varied from 5.28 to 10 g per day, and the duration of the interventions ranged from 56 to 140 weeks.

Risk of bias, and grade assessment

Table 2 summarizes the risk of bias assessed using the Cochrane risk-of-bias tool. All studies were considered to be of good quality. Following the GRADE approach, all outcomes were rated at moderate levels of evidence. However, the level of evidence was downgraded due to serious limitations related to imprecision. Additional details regarding the GRADE assessment are provided in Table 3.

Meta-analysis results

Fasting blood sugar

A meta-analysis of four RCTs [12, 16–18] demonstrated a significant reduction in serum FBS levels in the RD group compared to the placebo group (WMD: -5.45 mg/dl, 95% CI: -12.38 to 1.93; $P = 0.14$). There was

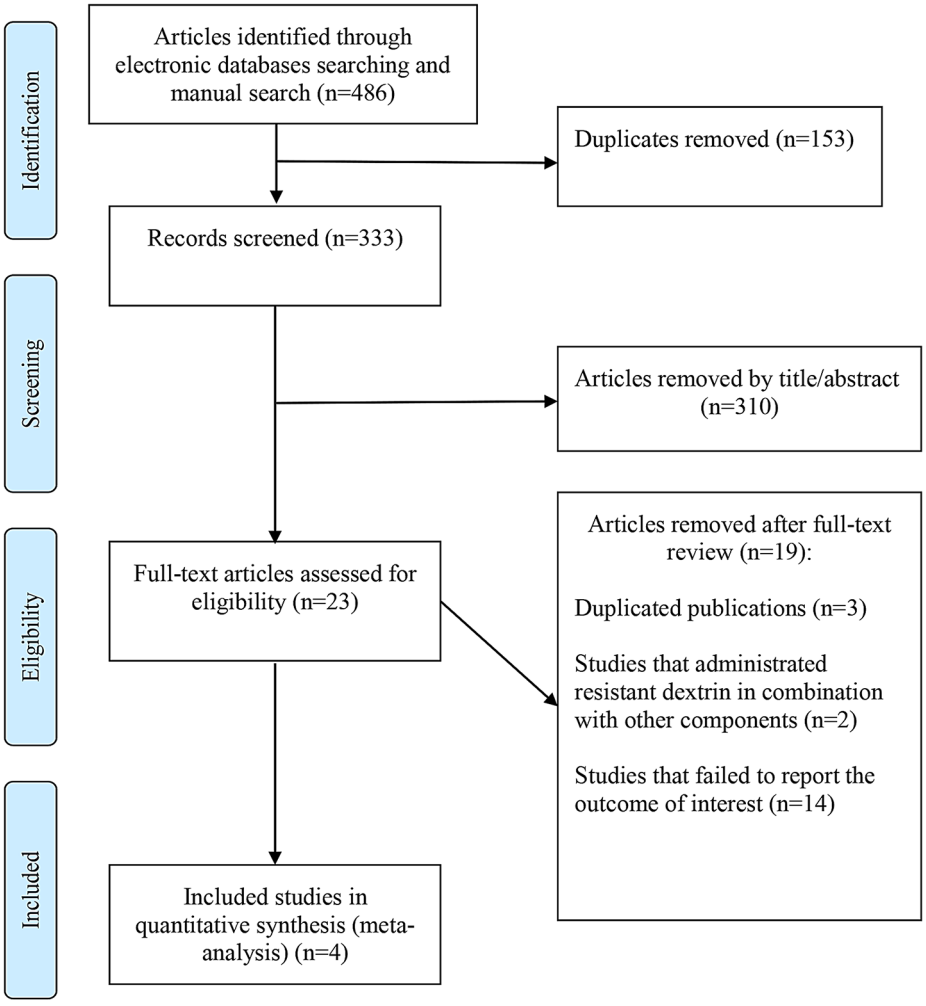

Fig. 1 Flow chart of the process of the study selection

Table 1 Characteristics of the included studies

Author (year)	Country	RCT design	Sample size	Mean age (year)	Sex	Dose (g/d)	Mean duration of diabetes (year)	Study duration (day)	Intervention	Control group	Outcome
Aliasgharzadeh (2015) [12]	Iran	Parallel	Intervention (30), Control (25)	49	Female	10	2	56	Resistant dextrin supplement	Maltodextrin	FBS, fasting insulin, HbA1c
Cai (2018) [16]	China	Parallel	Intervention (49), Control (50)	60	Both	6.3	8	84	45 g milk powder with inulin and resistant dextrin	45 g milk powder without inulin and resistant dextrin	FBS, fasting insulin, HbA1c
Mateo-Gallego (2019) [17]	Spain	Cross-over	Intervention (21), Control (22)	56	Both	5.28	NR	140	Alcohol-free beer containing RD and isomaltose	Regular alcohol free beer	FBS, fasting insulin, HbA1c
Saleh-Ghadimi (2022) [18]	Iran	Parallel	Intervention (33), Control (30)	47	Female	10	7	56	Resistant dextrin supplement	Maltodextrin	FBS, HbA1c

RCT, randomized controlled trial; Glycosylated hemoglobin; HbA1c, Fasting blood sugar; FBS, Not reported; NR

Table 2 Literature quality assessment based on Cochrane guidelines

First author (publication year)	Random Sequence Generation	Allocation concealment	Blinding of participants, personnel	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Other sources of bias
Aliasgharzadeh et al. (2015)	L	L	L	L	L	L	U
Cai et al. (2018)	L	L	L	U	L	L	U
Mateo-Gallego et al. (2020)	L	L	L	L	L	L	U
Saleh-Ghadimi et al. (2022)	L	L	L	U	L	L	U

L, low risk of bias; U, unclear; H, high risk of bias

Table 3 Quality of the evidence evaluated by GRADE

Outcome	Certainty assessment					Certainty[6]
	Risk of bias[1]	Inconsistency[2]	Indirectness[3]	Imprecision[4]	Publication bias[5]	
FBS	No serious limitation	Serious limitation	No serious limitation	Serious limitation	No serious limitation	Low
Fasting insulin	No serious limitation	Serious limitation	No serious limitation	Serious limitation	No serious limitation	Low
HbA1c	No serious limitation	No serious limitation	No serious limitation	Serious limitation	No serious limitation	Moderate

Glycosylated hemoglobin; HbA1c, Fasting blood sugar; FBS

[1] Risk of bias based on the Cochrane risk of bias tool. Only one study was rated as weak quality according to this checklist

[2] Downgraded if there was a substantial unexplained heterogeneity ($I^2 > 50\%$, $P < 0.10$) that was unexplained by subgroup analyses

[3] Downgraded if there were factors present relating to the participants, interventions, or outcomes that limited the generalizability of the results

[4] optimal information size was not met, or the 95% CI include the null value lower and upper bounds of the 95% CI were < 0.95 and > 1.05, respectively

[5] Downgraded if there was an evidence of publication bias using Egger's test

[6] Since all included studies were randomized clinical trials, the certainty of the evidence was graded as high for all outcomes by default and then downgraded based on pre specified criteria. Quality was graded as high, moderate, low, very low

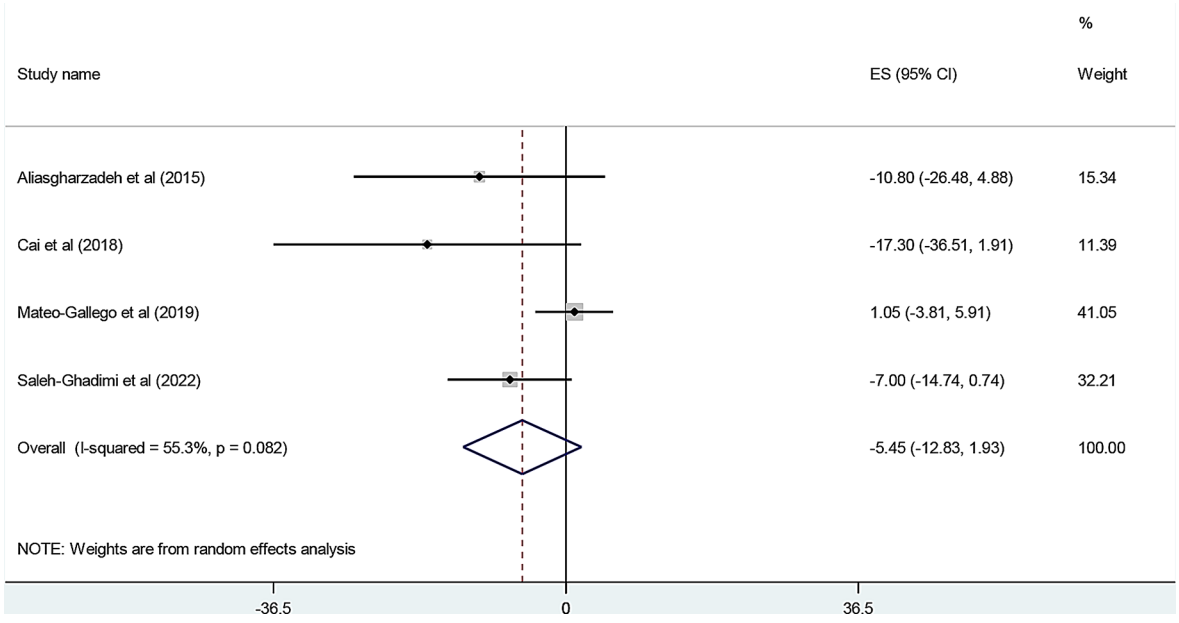

Fig. 2 Forest plot of the effect resistant dextrin supplementation on fasting blood sugar

considerable heterogeneity among the trials (I^2=55.3%, P=0.08) (Fig. 2). However, sensitivity analysis indicated that removing Mateo-Gallego et al. [17] study from the analysis would result in a significant effect of RD on FBS (WMD: -8.84 mg/dl, 95% CI: -15.37 to -2.31; P=0.008). Furthermore, no evidence of publication bias was found in the studies assessing the impact of RD supplementation on FBS (P=0.08).

Fasting insulin

A pooled analysis of three RCTs [12, 16, 17] revealed that there was no significant effect of RD supplementation on serum fasting insulin levels in the RD group compared to the control group (Hedges'g: -0.26; 95% CI: -0.74 to 0.21; $P = 0.28$). Additionally, there was considerable heterogeneity among the trials ($I^2 = 70.4\%$, $P = 0.03$) (Fig. 3). After excluding each trial individually, we found that no single study significantly influenced the overall effect sizes of serum fasting insulin levels. Furthermore, the Egger test indicated no evidence of publication bias ($P = 0.07$).

Glycosylated hemoglobin

The effect of RD supplementation on serum HbA1c levels was evaluated in four RCTs [12, 16–18]. The pooled data analysis revealed that RD supplementation significantly reduced the serum HbA1c levels in the intervention group compared to the control group (WMD: -0.30%; 95% CI: -0.56 to -0.03; $P = 0.02$) (Fig. 4). There was no heterogeneity among the trials ($I^2 = 0.0\%$, $P = 0.45$). However, sensitivity analysis indicated that removing Aliasgharzadeh et al. [12] (WMD: -0.27%; 95% CI: -0.62 to 0.08; $P = 0.13$), Cai et al. [16] (WMD: -0.29%; 95% CI: -0.65 to 0.06; $P = 0.10$), and Saleh-Ghadimi et al. [18] (WMD: -0.25%; 95% CI: -0.52 to 0.01; $P = 0.06$) articles from the analysis would result in a non-significant effect of RD on HbA1c levels. No evidence of publication bias was found in the studies investigating the impact of RD supplementation on HbA1c levels ($P = 0.12$).

Discussion

The present study investigated the effects of RD supplementation on glucose regulation markers in patients with T2D. To the best of our knowledge, this is the first systematic review and meta-analysis on this topic. The results indicated that RD supplementation can reduce HbA1c levels in patients with T2D; however, it did not significantly affect FBS or fasting insulin levels. Sensitivity analysis revealed that excluding certain studies could potentially change the direction of the results for FBS and HbA1c. Nevertheless, Egger's test showed no evidence of publication bias for the outcomes assessed. Overall, due to the limited number of included studies, the findings should be interpreted with caution.

RD, a type of non-digestible carbohydrate, have garnered interest for their potential positive effects on metabolic health [26]. Previous meta-analysis has indicated that consuming RD can lead to improved anthropometric measures [14]. Although only three trials were included in the analysis, the favorable outcomes associated with RD consumption suggest its potential effectiveness in regulating glycemic levels [14]. For individuals with T2D, effectively managing blood glucose and insulin levels is crucial for reducing disease-related risks. Further investigation into the effects of RD on glycemic control could contribute to the development of complementary dietary interventions aimed at improving diabetes management [27]. Our findings align with previous meta-analysis that indicates resistant starch can lower HbA1c levels in patients with metabolic syndrome and related disorders [28]. However, our results regarding FBS and insulin

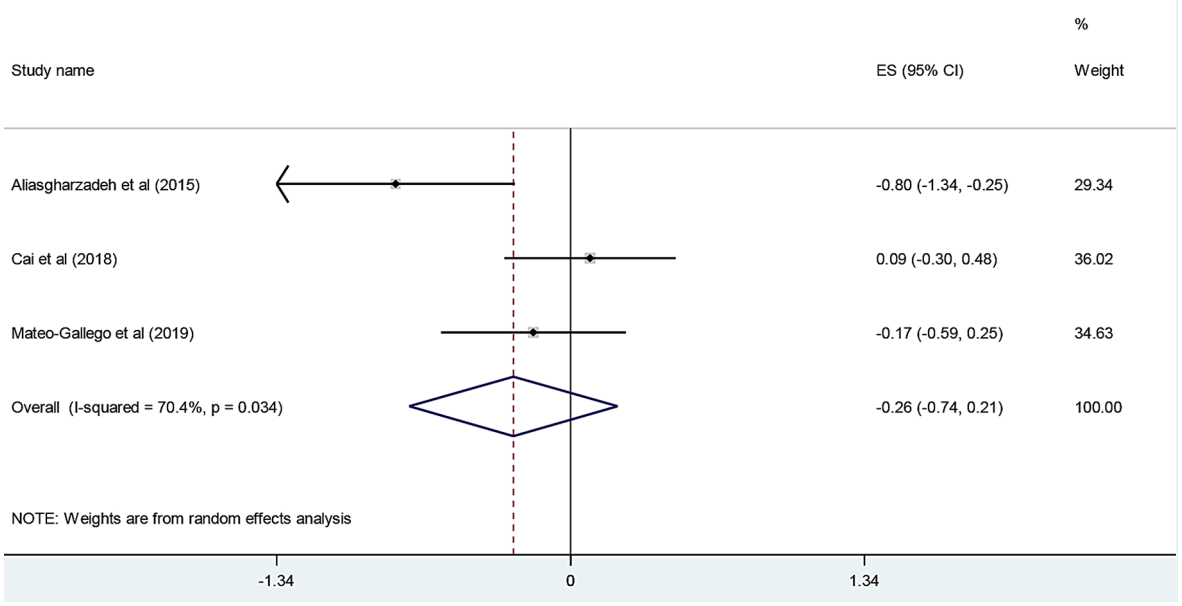

Fig. 3 Forest plot of the effect resistant dextrin supplementation on fasting insulin

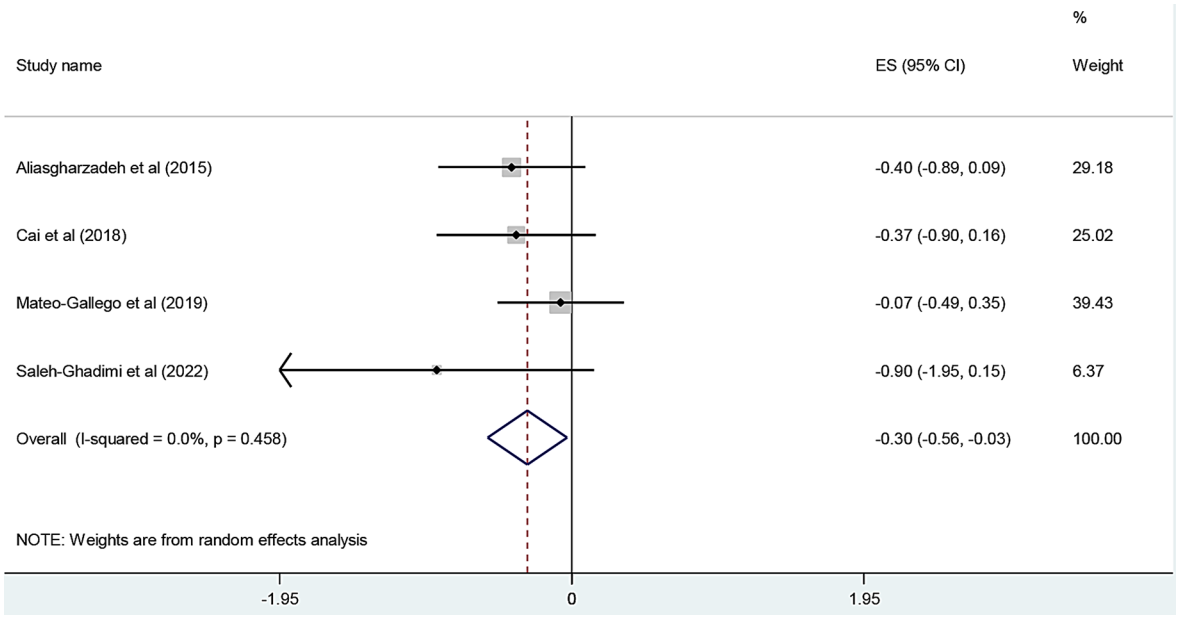

Fig. 4 Forest plot of the effect resistant dextrin supplementation on glycosylated hemoglobin

levels differ from those observed in that study. Another clinical trial found that consuming resistant starches for three months did not significantly affect blood sugar levels in patients with T2D compared to a control group [29]. However, another trial found that an alcohol-free beer containing isomaltulose and RD can significantly lower blood sugar levels in T2D patients [30]. These discrepancies may be due to variations in sample size, intervention duration, and participant characteristics.

The exact mechanism by which RD can improve glycemic indices requires further study. However, several biochemical processes have been suggested: (1) Reduction in glucose digestion and absorption: RD resists enzymatic digestion in the small intestine, leading to a slower release of glucose and preventing spikes in blood sugar levels after meals [11]; (2) Increased production of SCFAs: fermentation of RD in the colon produces SCFAs, particularly butyrate, which enhances insulin sensitivity [11, 12, 31]; (3) Improvement of gut microbiota composition: RD promotes the growth of beneficial gut bacteria that contribute to the regulation of glucose metabolism [32, 33]; (4) Reduction of systemic inflammation: lower levels of inflammation associated with diabetes can improve insulin sensitivity [12, 13]; (5) Enhancement of glucagon-like peptide-1 (GLP-1) secretion: GLP-1 is a hormone that regulates glucose metabolism and helps reduce appetite [34, 35]; (6) Improvement in insulin sensitivity: RD reduces insulin resistance, leading to better blood glucose control [16, 36]; (7) Reduction in hepatic glucose production: RD modulates metabolic signaling, which decreases hepatic gluconeogenesis [11, 31]; (8) Lowering of dietary glycemic index: incorporating RD into meals can reduce their overall glycemic impact [37, 38]; (9) improvement in lipid metabolism: RD helps balance blood lipid levels, which is beneficial for managing diabetes [12, 32]; (10) Reduction in HbA1c levels: improved long-term glycemic control due to stable blood glucose levels results in lower HbA1c levels [12, 16]. These mechanisms illustrate the potential of RD as a dietary intervention for managing T2D.

RDs are generally considered safe and well-tolerated, although some individuals may experience mild digestive issues. Common side effects include bloating, and abdominal discomfort, especially if consumed in large quantities or introduced suddenly into the diet. These symptoms are usually caused by the fermentation of RD in the colon, which produces gas [32, 39]. However, as the gut microbiota adapts, these effects often diminish over time. To minimize potential discomfort, it is advisable for individuals with sensitive digestion to gradually incorporate RDs into their diet [32].

This meta-analysis has several limitations that should be taken into account when interpreting the results. First, the number of RCTs included and the overall sample size were limited, which may have affected the statistical power of the findings. Additionally, the study protocol was not registered with PROSPERO, potentially introducing bias into our review. We also observed significant heterogeneity among studies for some of the assessed outcomes, and due to the limited number of studies, we could not conduct subgroup analyses. Furthermore, we were unable to examine the differential effects of RD in men and women separately, which is an important consideration. Given the small number of

studies, we could only assess FBS, fasting insulin, and HbA1c levels. In contrast, other relevant biomarkers such as postprandial glucose, the quantitative insulin sensitivity check index, and homeostatic model assessment for insulin resistance could not be evaluated. Eventually, it is important to interpret the findings of this meta-analysis with caution, as the included studies are limited to data from Iran, China, and Spain. As a result, the applicability of the results to other global populations may be limited.

Conclusion

In summary, preliminary evidence from a small number of RCTs suggests that supplementing with RD may effectively lower HbA1c levels in patients with T2D. However, the effect of RD on FBS and fasting insulin levels was not statistically significant. Before recommending RD supplementation for the prevention of diabetes or as an additional treatment for high blood glucose, further trials with larger sample sizes, longer durations, a range of RD dosages, and high quality are needed in the future.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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None.

Author contributions
M.R, D.A.S, and M.N contributed to the conception of research. M.R, H.D, and D.Sh searched databases, screened articles and extracted data. R.S and M.R performed statistical analysis; and all authors contributed to the writing and revision of the manuscript.

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Data availability
The original contributions listed in the study are included in the article/Supplementary Materials, further inquiries can be directed to the corresponding author.

Declarations

Ethical approval
Not applicable.

Consent for publication
Not applicable.

Patient consent
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Division of Nephrology & Hypertension, Department of Internal Medicine, Faculty of Medicine & Health Science, Universitas Lambung Mangkurat / Ulin Hospital, Banjarmasin, Indonesia
[2]Department of Obstetrics and Gynecology, College of Medicine, Al-Mustansiriya University, Baghdad, Iraq
[3]Marwadi University Research Center, Department of Computer Engineering, Faculty of Engineering & Technology, Marwadi University, Rajkot, Gujarat, India
[4]Department of Biotechnology and Genetics, School of Sciences, JAIN (Deemed to be University), Bangalore, Karnataka, India
[5]Centre for Research Impact & Outcome, Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab 140401, India
[6]Department of Pharmacy, Chandigarh Pharmacy College, Chandigarh Group of Colleges-Jhanjeri, Mohali, Punjab 140307, India
[7]Infertility and Reproductive Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran
[8]Social Determinants of Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran

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