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REVIEW

The effect of guar gum consumption on the lipid profile in type 2 diabetes mellitus: a systematic review and meta-analysis of randomized controlled trials

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ABSTRACT

Dyslipidemia is a common encounter in type 2 diabetes mellitus (T2DM) and the current strategies to manage it are still suboptimal. Subsequently, identifying newer molecules with lipid-lowering effects is necessary. A great deal of attention has been given in recent years to fiber supplements, e.g., guar gum. Thus, we screened and evaluated the quality of the evidence regarding the benefits of guar gum supplementation in T2DM and conducted a meta-analysis to assess the effects of this compound on serum lipids in T2DM. We conducted a comprehensive search in PubMed/Medline, Web of Science, Scopus, Google Scholar and Embase, from the inception of these databases until January 2021. In total, 11 papers were included based on the eligible criteria in our meta-analysis. The meta-analysis of the eligible trials demonstrated a significant reduction of total cholesterol (TC) (WMD: −20.32 mg/dL, 95% CI: −27.02, −13.62, $P < 0.001$) and low-density lipoprotein cholesterol (LDL-C) (WMD: −14.52 mg/dL, 95% CI: −20.69, −8.35, $P < 0.001$) following guar gum supplementation in T2DM patients. The subgroup analysis based on the dosage (g/day) of this compound revealed that ≥20 g/day of guar gum led to a notable decrease in triglyceride (TG) levels (WMD: −12.55 mg/dL, 95% CI: −23.72, −1.37, $P = 0.02$) versus < 20 g/day (WMD: −1.84 mg/dL, 95% CI: −32.18, 28.49, $P = 0.90$). Guar gum supplementation had no effects on high-density lipoprotein cholesterol (HDL-C) (WMD: 0.66 mg/dL, 95% CI: −0.95, 2.28, $P = 0.42$). Guar gum consumption has lipid-lowering effects when administered to patients with type 2 diabetes mellitus and it is particularly able to reduce TC, LDL-C and TG levels. Further research is however needed to confirm our findings.

KEYWORDS
Diabetes;
Guar gum;
HDL-C;
Gum;
LDL-C;
lipid profile;
triglycerides

Introduction

Patients with type 2 diabetes mellitus (T2DM) have an increased morbidity rate and are prone to develop a myriad of health complications, particularly if they their disease is poorly controlled (Deshpande, Harris-Hayes, and Schootman 2008). Dyslipidemia is a common finding in T2DM and an adequate control of the lipid profile is often difficult to achieve in T2DM patients (American Diabetes Association, 2002). Diet and lifestyle changes play major roles in the management of both dyslipidemia and T2DM (Samaha et al. 2017). When T2DM patients do not adhere to a balanced diet, the maximal efficacy of oral hypoglycemic agents is not achieved. It is believed that soluble fibers can lower serum lipids concentrations due to their high viscosity and solubility (Surampudi et al. 2016). In T2DM, diets rich in fiber have been shown to improve glycemic control and reduce serum lipids concentrations (Simons et al. 1982). The benefits of fiber on the metabolism of lipids and of carbohydrates has been mainly attributed to the consumption of soluble rather than insoluble fibers (Papathanasopoulos and Camilleri 2010). Dietary soluble viscous fibers can decrease postprandial glycemia and many published studies have also reported that soluble fibers can modulate cholesterol metabolism, effectively decreasing circulating cholesterol concentrations (Jenkins et al. 1978; Queenan et al. 2007).

Guar gum is a natural galactomannan extracted from the endosperm of Guar seeds. Guar partakes to a group of nonabsorbable carbohydrates and has displayed efficacy in reducing postprandial glucose levels, particularly when

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guar granules are sprinkled on food (Jenkins et al. 1977). Moreover, guar gum supplementation in T2DM for 48 weeks has been reported to improve the lipid profile (Groop et al. 1993). However, in a 6-month randomized controlled trial, guar gum did not lead to alterations of the lipid profile in patients diagnosed with T2DM versus healthy controls (Mcivor et al. 1986). Consequently, a final conclusion regarding the effects of guar gum on the lipid profile in T2DM has yet been reached as the results of the various studies conducted so far have been conflicting (Tuomilehto et al. 2009; Landin et al. 1992; Simons et al. 1982).

Thus, in order to find an answer to this research question, we screened and evaluated the quality of evidence regarding the effects of guar gum supplementation on the lipid profile in T2DM patients and conducted the present meta-analysis.

Material and methods

Search strategy

This study was conducted based on the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines (Moher et al. 2015). To find pertinent articles, we performed a comprehensive search in the PubMed/Medline, Web of Science, Scopus, Google Scholar and Embase databases from their inception until January 2021. We did not apply any language or time limits to the search. Medical subject headings (MeSH) and related keywords were employed to search these databases as follows: ("Chewing Gum" OR "Plant Gums" OR "Gum Arabic" OR "Tragacanth" OR "Karaya Gum" OR "Locust bean gum" OR "supercol U" OR "slocose" OR "guar gum" OR "supercol" OR "gum guar" OR "guar flour" OR "guaran") AND ("RCT" OR "Trial" OR "Intervention" OR "Control*" OR "Random*" OR "Clinical" OR "Assignment" OR "Placebo" OR "Allocation"). Furthermore, the lists of references of the related studies were hand-screened to avoid missing any eligible trials.

Study selection

Two investigators separately removed the duplicate publications and evaluated the titles, abstracts, or the full-texts of the identified papers. Lastly, the relevant articles were selected based on the following criteria: (1) The trials used guar gum as intervention.(2) The clinical trial studies were randomized. (3) The trials were performed in T2DM subjects aged ≥18 years and 4) The papers reported the serum lipids concentrations, namely total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) levels, at baseline and after the intervention. Furthermore, we excluded the studies without an appropriate control group, non-randomized trials, animal studies, commentaries, reviews, letters to editor, and the studies that assessed the effect of guar gum intake in combination with other compounds.

Data extraction

After the papers were reviewed independently by two authors, the following data were extracted from each randomized controlled trial (RCT): the mean and the standard deviation (SD) at the baseline and at the end of the intervention for TC, LDL-C, HDL-C and TG, the year of publication, the name of the first author, the country in which the RCT was executed, the sex of the participants, the number of participants in the intervention and control groups, the mean age (years), the duration of the intervention and the gum dosage (g/day).

Quality assessment

The Cochrane Risk of Bias Tool (Higgins and Wells 2011) was employed by two researchers to ascertain the potential risks of bias of the RCTs. The quality assessment tool analyzes the following domains: allocation concealment, blinding, adequacy of random sequence generation, detection of incomplete outcome information, selective outcome reporting and other potential sources of bias.

Statistical analysis

The statistical analysis was executed using STATA version 14.0 (Stata Corp, College Station, TX, USA). The weighted mean difference (WMD) and random effects model were used to generate the combined effect sizes. When data were reported in a different format, standard calculations were done to obtain the mean and SD (Higgins 2011; Hozo, Djulbegovic, and Hozo 2005). For example, if the SD of the change was missing, we derived it using the next formula: SD changes = square root $[(SD_{baseline}^2+SD_{end}^2) - (2\times R\times SD_{baseline}\times SD_{end})]$. The I-squared ($I^2$) statistic was applied to examine the source of heterogeneity among the RCTs. Heterogeneity was defined as $I^2 > 50\%$ (Higgins et al. 2003). A pre-defined subgroup analysis based on the dose and the duration of the intervention was conducted to ascertain the potential sources of heterogeneity among the RCTs. We appraised the publication bias using funnel plot figures and the Egger's test (Egger et al. 1997). A sensitivity analysis was run to evaluate the influence of each arm on the overall result using the leave-one-out method.

Results

Study selection

Figure 1 details the search strategy and the selection process. After searching in the aforementioned databases, 2267 records were selected of which 516 duplicate

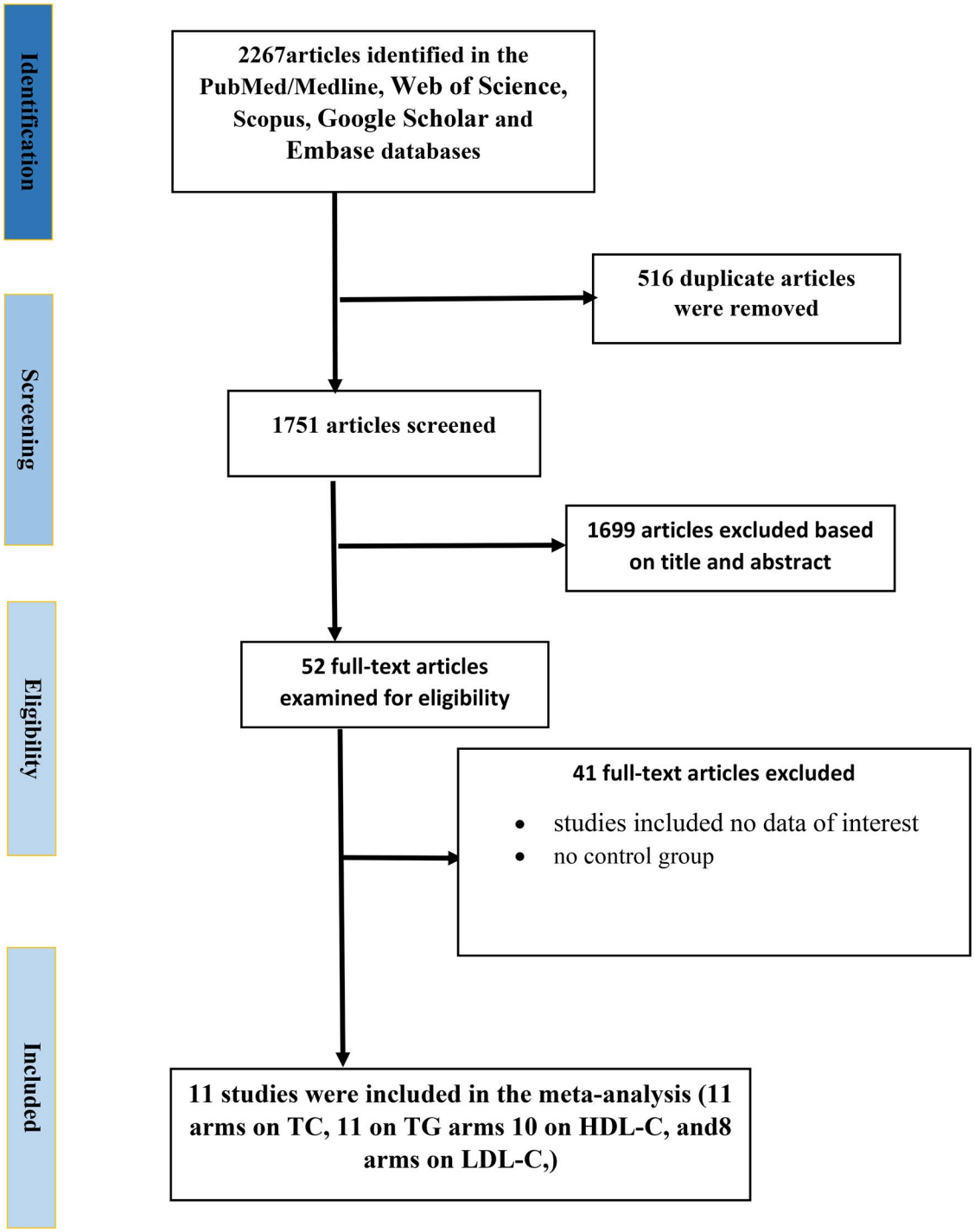

Figure 1. Flow chart mapping out the studies surveyed and included into the meta-analysis.

publications were removed. A total of 1751 articles were reviewed based on their abstracts and/or titles and based on this evaluation 1699 papers were removed. Furthermore, the full-texts of 52 manuscripts were screened. Finally, 11 papers which met the eligibility criteria of our research were included in the meta-analysis (Babiker et al. 2017; Dall'Alba et al. 2013; Thakur et al. 2009; Vuorinen-Markkola, Sinisalo, and Koivisto 1992; Laajam et al. 1990; Uusitupa et al. 1989; Peterson et al. 1987; Fuessl et al. 1987; Vaaler et al. 1986; Farrell, Owens, and Tomkin 1986; Mcivor et al. 1986).

Characteristics of the included studies

The characteristics of the 11 eligible RCTs are depicted in Table 1 (Babiker et al. 2017; Dall'Alba et al. 2013; Thakur et al. 2009; Vuorinen-Markkola, Sinisalo, and Koivisto 1992; Laajam et al. 1990; Uusitupa et al. 1989; Peterson et al. 1987; Fuessl et al. 1987; Vaaler et al. 1986; Farrell, Owens, and Tomkin 1986; Mcivor et al. 1986). The papers were published between 1985 and 2018. The RCTs were executed in Brazil, Sudan, Canada, Finland, Norway, Saudi Arabia, Ireland, The United States of America, Australia and the United Kingdom.

Table 1. Characteristics of the eligible trials.

Author, year	Country	Sex	Duration	Participants age (year)	Sample size gum/Placebo	Gum dosage (g/d)
Rasha Babiker et al. (2017)	Sudan	Both	3 months	50.09	46/45	30 g/day
v. Dall'Alba et al. (2013)	Brazil	Both	6 weeks	62	23/21	10 g/day
Goutam Thakur et al. (2009)	Canada	Both	6 months	48.62	60/60	5 g/day
Helena Vuorinen-Markkola, Sinisalo, and Koivisto (1992)	Finland	Both	6 months	39.3	9/8	20 g/day
Mohamed A. Laajam et al. (1990)	Saudi Arabia	Both	18 weeks	51.5	33/23	15 mg/day
Matti Uusitupa et al. (1989)	Finland	Both	3 months	nr	20/19	15 g/day
R. W. Farrell, Owens, and Tomkin (1986)	Ireland	Both	4 weeks		9/9	15 g/day
H. S. Fuessl et al. (1987)	USA	Both	16 weeks	61.3	9/9	15 g/day
D. B. Peterson et al. (1987)	United Kingdom	Both	4 weeks	47–69	16/16	8.3 g/day
S. Vaaler et al. (1986)	Norway	Both	6 weeks	27	14/14	29 g/day
Michael E. Mcivor et al. (1986)	Australia	Both	3 months	49	8/8	6.6 g/day

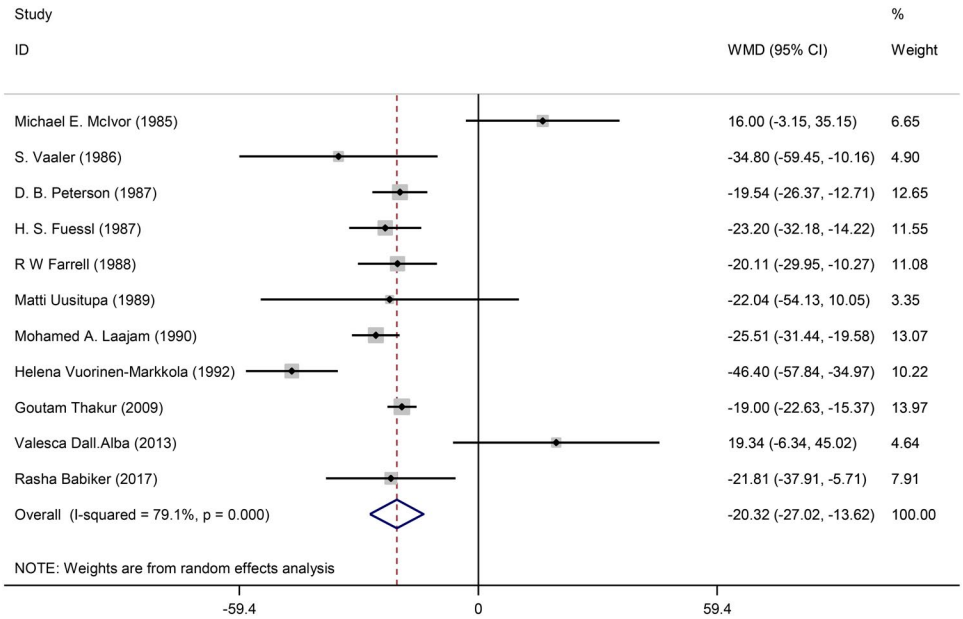

Figure 2. Forest plot of the randomized controlled trials investigating the effects of guar gum intake on Total Cholesterol (TC).

The mean age of the recruited subjects varied from 27 years to 69 years. The guar gum supplementation dose ranged from 5 g/day to 30 g/day. The duration of the intervention ranged from 4 weeks to 6 months. The evaluation of the risk of bias using The Cochrane Risk of Bias Tool for Randomized Controlled Trials is depicted in Supplementary Table 1.

Findings from the Meta-analysis

Effects of guar gum intake on TC levels

Overall, the meta-analysis of 11 RCTs with a sample size of 479 participants (controls: 246 subjects; guar gum supplementation: 232 subjects) revealed a significant reduction in TC (WMD: −20.32 mg/dL; 95% CI: −27.02, −13.62; $P < 0.001$) following guar gum consumption. However, a significant between-study heterogeneity was detected ($I^2 = 79\%$; $P < 0.001$) (Figure 2). The subgroup analysis based on the dosage (g/day) employed revealed that ≥20 g/day of guar gum led to a more notable decrease in TC (WMD: −44.34 mg/dL, 95% CI: −54.72, −33.97, $P < 0.001$) versus <20 g/day (WMD: −17.38 mg/dL, 95% CI: −23.24, −11.51, $P < 0.001$). In addition, guar gum supplementation for <3 months (WMD: −23.03 mg/dL, 95% CI: −33.96, −12.10, $P < 0.001$) resulted in a more pronounced decrease in TC versus ≥3 months of supplementation (WMD: −16.72 mg/dL, 95% CI: −26.14, −7.30, $P < 0.001$) (Table 2).

Table 2. Subgroup analysis to evaluate the effect of gum consumption on the lipid profile.

Subgrouped by	No. of trials	WMD 95% CI	P Value	P for heterogeneity	I^2 (%)
TG					
Dosage					
<20 g	8	−1.845 −32.188 28.497	0.905	0.000	95
≥20 g	3	−12.554 −23.729 −1.379	0.028	0.964	0.0
Intervention duration (months)					
<3	4	−6.671 −58.445 45.103	0.801	0.000	96
≥3	7	−7.762 −18.903 3.379	0.172	0.118	40
LDL-c					
Dosage					
<20 g	6	−11.052 −17.089 −5.016	0.000	0.003	72
≥20 g	2	−32.015 −41.825 −22.205	0.000	0.570	0.0
Intervention duration (months)					
<3	4	−13.899 −26.281 −1.517	0.001	0.000	83
≥3	4	−14.188 −22.561 −5.814	0.028	0.025	68
HDL-C					
Dosage					
<20 g	7	0.857 −0.358 2.071	0.167	0.445	0.0
≥20 g	3	0.341 −7.241 7.923	0.930	0.030	71
Intervention duration (months)					
<3	5	0.992 −1.311 3.294	0.864	0.150	40
≥3	5	0.239 −2.497 2.974	0.399	0.218	30
TC					
Dosage					
<20 g	9	−17.382 −23.245 −11.519	0.000	0.001	70.1
≥20 g	2	−44.347 −54.723 −33.972	0.000	0.403	0.0
Intervention duration (months)					
<3	5	−23.034 −33.960 −12.108	0.001	0.000	85
≥3	6	−16.722 −26.140 −7.305	0.000	0.013	65

Effects of guar gum intake on HDL-C levels

Overall, the meta-analysis of 10 RCTs with a sample size of 417 participants (controls: 211 subjects; guar gum supplementation: 206 subjects) revealed that guar gum supplementation did not lead to significant changes in HDL-C (WMD: 0.66 mg/dL; 95% CI: −0.95, 2.28; P = 0.42). Between-study heterogeneity was not detected (I^2 = 32%; P < 0.001) (Figure 3).

Effects of guar gum intake on LDL-C levels

Overall, the meta-analysis of 8 RCTs with a sample size of 356 participants (controls: 180 subjects; guar gum supplementation: 176 subjects) revealed that guar gum supplementation led to significant reduction in LDL-C (WMD: −14.52 mg/dL, 95% CI: −20.69, −8.35, P < 0.001). However, a significant between-study heterogeneity was detected (I^2 = 32%; P < 0.001) (Figure 4). The subgroup analysis based on the guar gum dosage (g/day) revealed that a dose of guar gum ≥2 0 g/day was more efficient in reducing LDL-C (WMD: −44.34 mg/dL, 95% CI: −54.72, −33.97, P < 0.001) versus a dose <20 g/day (WMD: −17.38 mg/dL, 95% CI: −23.24, −11.51, P < 0.001). In addition, supplementation with guar gum for <3 months led to a more notable decrease of LDL-C (WMD: −23.03 mg/dL, 95% CI: −33.96, −12.10, P = 0.001) versus ≥3 months (WMD: −16.72 mg/dL, 95% CI: −26.14, −7.30, P = 0.001) (Table 2).

Effects of guar gum intake on TG levels

Overall, the meta-analysis of 11 RCTs with a sample size of 526 participants (controls: 270 subjects; guar gum supplementation: 256 subjects) revealed that guar gum supplementation did not alter TG concentrations (WMD: −6.80 mg/dL, 95% CI: −26.29, 12.69, P = 0.49). However, a significant between-study heterogeneity was detected (I^2 = 92%; P < 0.001) (Figure 5). The subgroup analysis based on the dosage (g/day) revealed that a guar gum supplementation dose ≥20 g/day (WMD: −12.55 mg/dL, 95% CI: −23.72, −1.37, P = 0.02) reduced TG levels in a significant manner versus a dose <20 g/day (WMD: −1.84 mg/dL, 95% CI: −32.18, 28.49, P = 0.90) (Table 2).

Sensitivity analysis

The results remained strong after the sequential removal of each RCT after applying the leave-one-out method (Supplementary Figure 1).

Publication bias

The Egger's test and visual inspection of the funnel plots revealed no evidence of publication bias in the current study for TC (P = 0.77), LDL-C (P = 0.41), HDL-C (P = 0.99) and TG (P = 0.72) (Figure 6).

Discussion

Even though several herbal medicines and foods have been used in the management of various metabolic disorders (Derosa et al. 2020; Santos, Price, and Bueno 2020), evidence-based medicine had demonstrated that fiber-rich diets can positively influence glycemic control and improve the lipid profile (Mohamed, Gadour, and Adam 2015; Vuorinen-Markkola, Sinisalo, and Koivisto 1992). Soluble fibers are more likely to exert lipid-lowering properties versus insoluble fibers in the treatment of dyslipidemia (Rideout et al. 2008). Guar gum which is a soluble fiber has been reported to alleviate serum TC, LDL-C and TG by

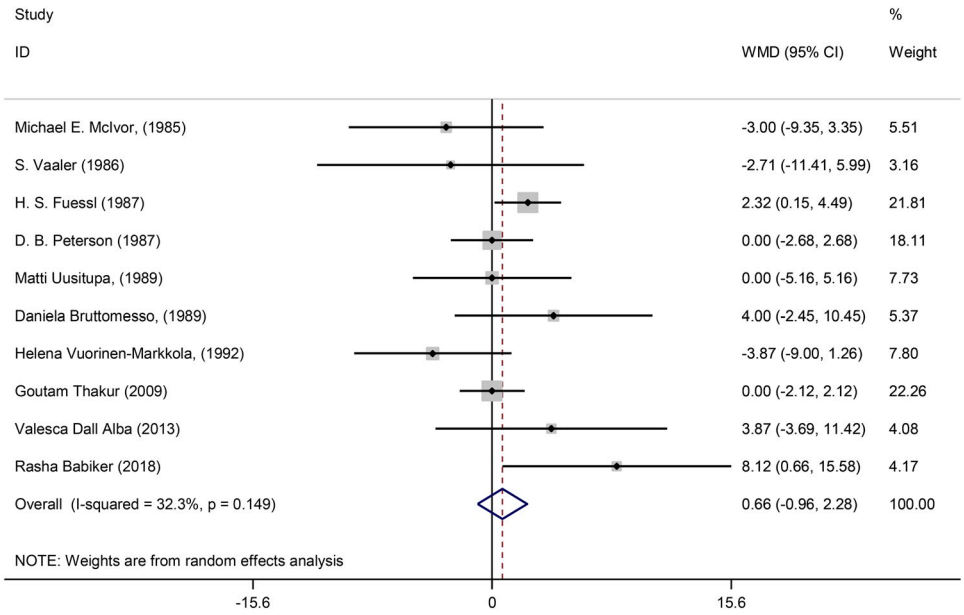

Figure 3. Forest plot of the randomized controlled trials investigating the effects of guar gum consumption on HDL-C.

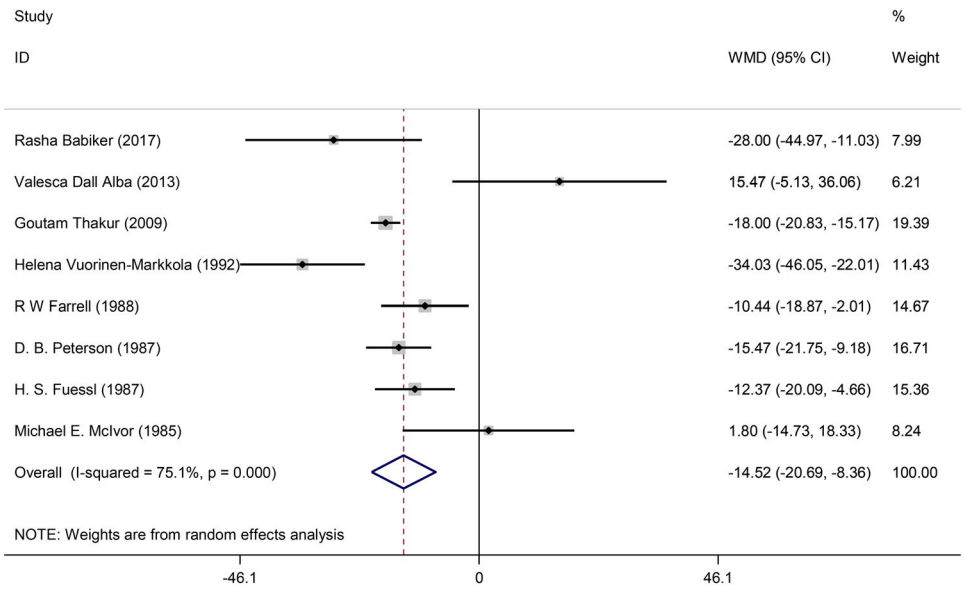

Figure 4. Forest plot of the randomized controlled trials investigating the effects of guar gum intake on LDL-C.

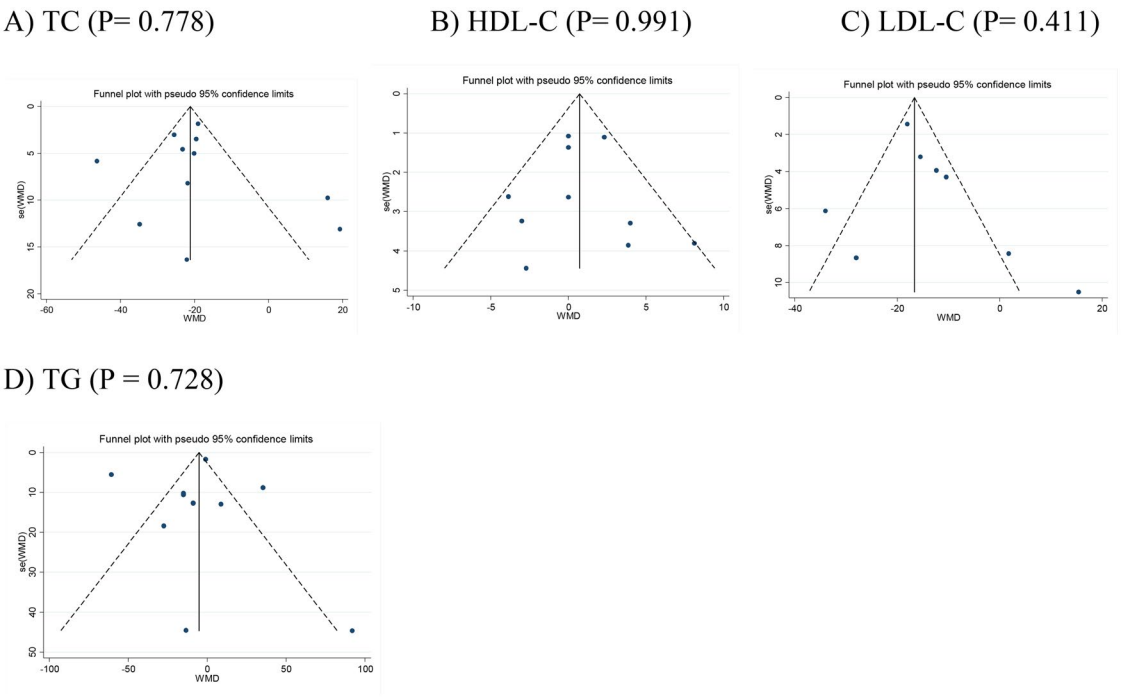

Figure 6. Funnel plot of the weighted mean difference (WMD) versus the s.e. of the weighted mean difference (WMD).

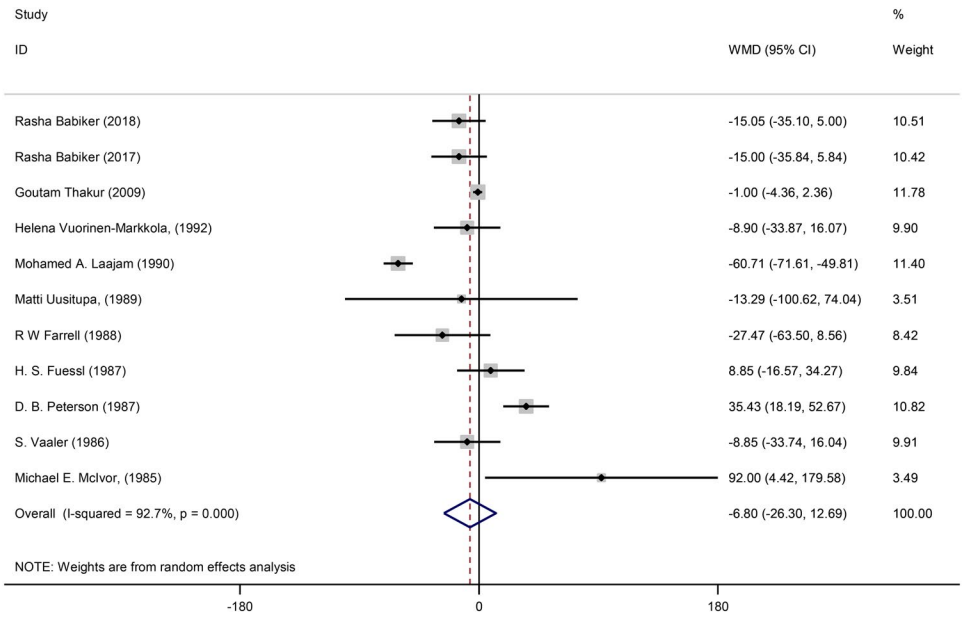

Figure 5. Forest plot of the randomized controlled trials examining the effects of guar gum consumption on TG.

modulating lipid metabolism and influencing the gut-liver axis and may emerge as a key compound in decreasing cardiovascular risk. Its reported effects are different, however, based on the duration of the intervention, the daily dose and the disorders in which supplementation has been investigated (Mohamed, Gadour, and Adam 2015; Vuorinen-Markkola, Sinisalo, and Koivisto 1992; Butt et al. 2007).

The current systematic review and meta-analysis of 11 RCTs was performed to assess the effects of guar gum supplementation on serum lipids in subjects diagnosed with T2DM. The age of the patients ranged from 27 years to 69 years, the guar gum dosage investigated ranged from 5 g/day to 30 g/day and the intervention duration lasted from 4 weeks to 6 months. In this meta-analysis, guar gum supplementation was found to reduce TC by −20.32 mg/dL (95% CI: −27.02, −13.62) and LDL-C by −14.52 mg/dL (95% CI: −20.69, −8.35) in T2DM subjects versus controls. However, guar gum intervention did not alter HDL-C (WMD: 0.66 mg/dL, 95% CI: −0.95, 2.28) and decreased TG levels only when

prescribed in a dose ≥20 g/day (WMD: −12.55 mg/dL, 95% CI: −23.72, −1.37).

Compared to other studies, the mean 20 mg/dL decrease of TC detected in our study is similar to the TC reduction depicted in other publications or slightly higher. This reduction in TC is clinically significant and would definitely shift high TC levels toward the normal range of 200 mg/dL in selected cases (Lin et al. 2021; Craig et al. 2000; Jeong et al. 2018). Animal studies have also demonstrated the efficacy of guar gum in reducing TC levels particularly via decreasing the absorption of cholesterol (Pellizzon et al. 2007).

In our meta-analysis, we detected a mean decrease of 15 mg/dL in LDL-C. This value is slightly lower than the one reported in another meta-analysis exploring the properties of the same compound (Lin et al. 2021). However, its effect on LDL-C is more notable versus the effects of other natural supplements, i.e., alpha-lipoic acid (Mousavi et al. 2019) or artichoke leaf extract (Sahebkar et al. 2018).

In our meta-analysis, guar gum consumption had no significant effects on HDL-C levels. Although an increase in HDL-C concentration was expected due to the increased fiber intake, guar gum failed to exhibit such benefits. This result was also supported by the findings of other studies (Dall'Alba et al. 2013; Mohamed, Gadour, and Adam 2015).

In terms of TG concentrations, guar gum lowered TG levels by 12.55 g/dL only when administered in a dose ≥20 g/day. Another meta-analysis has also reported a similar effect (Lin et al. 2021). However, other gums, e.g., bitter almond gum, have been shown to decrease TG levels and thus further research is needed to identify other compounds which can lead to a more notable reduction in TG (Chahibakhsh et al. 2019).

In our meta-analysis, we discovered a more pronounced reduction of TC and LDL-C in the studies with duration of <3 months versus of ≥3 months. This finding is also supported by the results of other previously published papers (Lin et al. 2021). This effect might derive from the fact that patients may not be compliant to supplementations that last for a long period of time (Crichton et al. 2012).

Guar gum consumption can lead to changes in TC and LDL-C concentrations via different mechanisms. Its TC-reduction properties are blamed on its high viscosity as in vivo studies have pointed out that the viscosity of guar gum can influence the digestion and absorption of food. Other studies have reported that guar gum increases the viscosity and the weight of chime in the stomach of murine models. This results in prolonged intestinal chime retention and delayed emptying of the gastric content. This process will ultimately slow down the food digestion process and may explain why TC levels declined following the ingestion of this compound. Moreover, by delaying the emptying of the gastric content, there will be an increase in satiety and hence the food intake will subsequently decrease (Chen et al. 2020; Fabek and Goff 2015). Moreover, guar gum ingestion might have only influenced LDL-C and not HDL-C levels because LDL-C is the main carrier of endogenous cholesterol and accounts for three-fourth of the circulating lipoprotein cholesterol in the body (Jacobson et al. 2015). Furthermore, its effects on TG may be attributable to the regulation of TG homeostasis through the interaction between the smooth endoplasmic reticulum and the lipid droplets in the periphery of hepatocytes (Rai et al. 2017).

TC and LDL-C are known as major contributors in the installment of cardiovascular disease and promote the development of atherosclerotic plaques (Alique et al. 2015) (Gao et al. 2018).

Thus, based on our results, supplementation with guar gum can emerge as an inexpensive method of promoting a healthy lifestyle and have a positive impact on the prevention of cardiovascular diseases. However, due to its high viscosity, patients might not be compliant to this therapy (Rushdi, Pichard, and Khater 2004).

Strengths of the paper

Our systematic review and meta-analysis can serve as a guideline for nutritionists and dieticians who manage individuals with T2DM and who can administer 20 g/day of guar gum for 3 months in order to effectively decrease TC, LDL-C and TG levels in their patients.

Limitations of the paper

Some of the limitations of the paper are the heterogeneity of the investigated population and that the effect of guar gum on cardiovascular endpoints, e.g., stroke and death, could not be assessed.

Conclusions

Guar gum consumption can alter the lipid profile in T2DM patients, particularly by decreasing TC, LDL-C and TG concentrations.

Disclosure statement

The authors have no conflict of interest to declare.

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