

# Dietary ginger as a traditional therapy for blood sugar control in patients with type 2 diabetes mellitus

## A systematic review and meta-analysis

Fang-yan Huang, MD\*, Ting Deng, MD, Lian-xin Meng, MD, Xin-ling Ma, MD

### Abstract

**Background:** Ancient medical practitioners used to encourage dietary supplements and herbal medicine for the treatment of type 2 diabetes mellitus (T2DM). Ginger (*Zingiber officinale*), is a nontoxic spice with negligible side effects, and is considered safe by the food and drug administration. In this analysis, we aimed to systematically compare fasting blood sugar (FBS) and glycosylated hemoglobin (HbA1c) at baseline versus at follow-up in T2DM patients who consumed and who did not consume ginger.

**Methods:** A literature search was carried out through MEDLINE, Embase, the Cochrane Central, and www.ClinicalTrials.gov for English-published trials comparing glucose parameters in T2DM patients who were assigned to ginger consumption versus a control group. All the participants were patients with T2DM who were either assigned to ginger therapy (1600–4000 mg daily) or to a control group. FBS and HbA1c were assessed in the ginger and control groups, respectively, from baseline to follow-up to observe any significant change. Weight mean difference (WMD) with 95% confidence intervals (CI) was calculated to represent the analysis which was carried out by the RevMan 5.3 software.

**Results:** Eight randomized trials consisting of a total number of 454 participants with T2DM were included in this analysis. At first, FBS was compared in patients with T2DM from baseline prior to ginger consumption until follow-up after ginger consumption. The results showed no significant difference in FBS (WMD: 1.38, 95% CI: [−0.53–3.30];  $P = .16$ ). For the T2DM patients who did not consume ginger, no significant difference in FBS was observed (WMD: −0.27, 95% CI: [−5.09–4.54];  $P = .91$ ). However, a significantly improved HbA1c from baseline to follow-up was observed in those participants with ginger consumption (WMD: 0.46, 95% CI: [0.09–0.84];  $P = .02$ ) whereas in the control group, no significant difference in HbA1c was observed (WMD: −0.23, 95% CI: [−0.60–0.14];  $P = .22$ ).

**Conclusion:** This analysis involving patients with T2DM showed no significant difference in FBS with ginger consumption. However, dietary ginger significantly improved HbA1c from baseline to follow-up showing that this natural medicine might have an impact on glucose control over a longer period of time in patients with T2DM.

**Abbreviations:** FBS = fasting blood sugar, HbA1c = glycosylated hemoglobin, T2DM = type 2 diabetes mellitus.

**Keywords:** fasting blood sugar, ginger consumption, glycosylated hemoglobin, natural therapy, type 2 diabetes mellitus

Editor: Yung-Hsiang Chen.

This meta-analysis is based on previously conducted studies and does not contain any studies with human participants or animals performed by any of the authors.

All data generated or analyzed during this study are included in this published article.

No funding or sponsorship was received for the publication of this article. The article processing charges were funded by the authors.

The authors have no conflicts of interest to disclose.

Youjiang Medical University for Nationalities, Baise, Guangxi, P.R. China.

\* Correspondence: Fang-yan Huang, Youjiang Medical University for Nationalities, No. 98 Chengxiang Road, Baise, Guangxi, 533000, P.R. China (e-mail: Katyhf@163.com).

Copyright © 2019 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the Creative Commons Attribution License 4.0 (CCBY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Medicine (2019) 98:13(e15054)

Received: 11 October 2018 / Received in final form: 5 February 2019 /

Accepted: 5 March 2019

<http://dx.doi.org/10.1097/MD.0000000000015054>

### 1. Introduction

Type 2 diabetes mellitus (T2DM) is still a global issue in this era of 2018. Several new therapies have been tried to maintain the blood sugar level to a normal level<sup>[1–4]</sup> in order to prevent complications associated with this chronic disease. However, oral antidiabetic medications might sometimes be associated with unwanted side effects leading to drug discontinuation.<sup>[5]</sup> In order to improve this situation, diabetes therapies associated with less adverse events would be required.<sup>[6]</sup>

From the perception of Chinese medicine, an individual categorized as having an unhealthy body constitution would develop progressive chronic disorders such as diabetes mellitus and heart diseases. Yin-deficiency, Yang-deficiency, and Yin-Yang deficiencies were observed in patients with T2DM. Hence, ancient medical practitioners and elderly Chinese people used to encourage dietary supplements and herbal medicine for the treatment of T2DM.<sup>[7]</sup> Traditional Chinese medicine has shown vital benefits in the treatment of patients with T2DM and other diseases.<sup>[8–13]</sup> Spices have long been known for their anti-inflammatory, antioxidant, and antidiabetic properties.<sup>[14]</sup> Today, new researchers are interested to further discover and explore the biopharmaceutical activities of these dietary supplements.<sup>[15–16]</sup>

Ginger, also known as *Zingiber officinale*, is a nontoxic spice with negligible side effects, and is considered safe by the food and drug administration (FDA).<sup>[17]</sup> Several researches have shown ginger to be beneficial in patients with T2DM.<sup>[18]</sup> However, most of the studies were literature and systematic reviews lacking data evidence. There was a need for data analysis, which, with evidence, could probably show the beneficial effects of ginger in patients with T2DM.

In this analysis, we aimed to systematically compare fasting blood sugar (FBS) and glycated hemoglobin (HbA1c) at baseline versus at follow-up in T2DM patients who consumed and who did not consume ginger.

## 2. Methods

### 2.1. Literature search: searched databases, searched terms, inclusion and exclusion criteria

A literature search was carried out through MEDLINE (PubMed), Embase, the Cochrane Central database, and www.ClinicalTrials.gov for English-published trials (until July 2018) comparing glucose parameters in T2DM patients who were assigned to ginger supplement and a control group respectively.

The following search terms were used:

- Ginger and type 2 diabetes mellitus;
- Ginger and glucose control;
- Ginger and T2DM;
- Ginger and diabetes mellitus;
- *Zingiber officinale* and diabetes mellitus;
- *Zingiber officinale* and glucose control;
- *Zingiber officinale* and type 2 diabetes mellitus.

The following inclusion criteria were considered:

- Randomized trials involving patients with T2DM;
- Trials comparing FBS and HbA1c in participants who were assigned to a ginger and a control group;
- Trials reporting FBS and HbA1c at baseline and at follow-up.

The following exclusion criteria were considered:

- Nonrandomized trials, systematic reviews, meta-analyses, and case studies;
- Trials which did not involve patients with T2DM;
- Trials that did not report FBS and HbA1c;
- Trials that were not based on patients who were assigned to ginger supplements;
- Trials that included data which could not be used in this meta-analysis;
- Duplicated studies.

### 2.2. Participants, endpoint, and follow-up time period

All the participants were patients with T2DM who were either assigned to ginger therapy (1600–4000 mg daily) or to a control group as shown in Table 1.

Fasting blood sugar and HbA1c were assessed in the ginger and the control groups, respectively, at baseline versus at follow-up to observe for any significant change.

The significance of fasting blood sugar was to check whether blood glucose was under control on a daily basis.

The significance of HbA1c was to check blood sugar control over a longer period of time (1–2 months).

A follow-up time period of 8 to 12 weeks were considered relevant to this meta-analysis as shown in Table 1.

### 2.3. Data extraction and quality assessment

The type of study, the total number of T2DM participants assigned to the ginger and the control groups, the respective average FBS and HbA1c which were reported, and the baseline features of the participants were carefully extracted by 4 authors (FYH, TD, LXM, and XLM). Any disagreement which followed was considered and then solved by the corresponding author.

The quality assessment of the trials was carried out with reference to the criteria suggested by the Cochrane Collaboration.<sup>[19]</sup>

Sensitivity analysis was carried out by a method of exclusion.

### 2.4. Statistical analysis

Data that were extracted to be used in this analysis consisted of mean, standard deviation (sd), and the number of participants from each trial. For the continuous variable, weight mean difference (WMD) with 95% confidence intervals (CI) was calculated to represent the analysis which was carried out by the RevMan 5.3 software.

Heterogeneity was assessed by the  $Q$  statistic test whereby a result was considered statistically significant if the  $P$  value obtained was less or equal to .05.

Heterogeneity was also assessed by the  $I^2$  test, whereby a higher  $I^2$  represented a higher heterogeneity.

The statistic effect models which were used during the analysis included a fixed effect model ( $I^2 < 50\%$ ) or a random effect model ( $I^2 > 50\%$ ).

### 2.5. Compliance with ethical guidelines

Ethical approval was not required for this study since it did not involve experiments with animals or humans performed by any of the authors.

**Table 1**

#### Outcomes, follow-up time periods.

Trials	Participants	Proposed therapy	Outcome to be assessed	Follow-up time period
Arablou 2014 <sup>[21]</sup>	T2DM	1600 mg ginger	Fasting blood sugar, HbA1c	12 weeks
Arzati 2017 <sup>[22]</sup>	T2DM	2000 mg ginger	Fasting blood sugar, HbA1c	10 weeks
Azimi 2015 <sup>[23]</sup>	T2DM	3000 mg ginger	Fasting blood sugar, HbA1c	8 weeks
Bordia 1997 <sup>[24]</sup>	T2DM	4000 mg ginger	Fasting blood sugar	12 weeks
Khandouzi 2015 <sup>[25]</sup>	T2DM	2000 mg ginger	Fasting blood sugar, HbA1c	12 weeks
Khosravi 2014 <sup>[26]</sup>	T2DM	3000 mg ginger	Fasting blood sugar, HbA1c	8 weeks
Mahluji 2013 <sup>[27]</sup>	T2DM	2000 mg ginger	Fasting blood sugar, HbA1c	8 weeks
Shidfar 2015 <sup>[28]</sup>	T2DM	3000 mg ginger	Fasting blood sugar, HbA1c	12 weeks

HbA1c = glycated hemoglobin, T2DM = type 2 diabetes mellitus.

### 3. Results

#### 3.1. Search outcomes

The PRISMA reporting guideline was applied.<sup>[20]</sup> Search databases resulted in a total number of 205 publications. Following an initial assessment, 178 publications were eliminated due to nonrelevance.

Twenty-seven (27) full text articles were assessed for eligibility.

Further assessment of the full-text articles was carried out and more publications were eliminated for the following reasons:

- They were systematic reviews and meta-analyses (2);
- They were observational cohorts and case studies (4);
- They were based on healthy volunteers (1);
- They were duplicated studies (12).

Finally, 8 trials<sup>[21–28]</sup> were included in this analysis as shown in Figure 1.

#### 3.2. Main features of the trials and baseline characteristics of the participants

Eight randomized trials with a total number of 454 participants with T2DM were included in this analysis. Two hundred and

forty five (245) participants were assigned to the ginger group whereas 209 participants were assigned to the control group. The data were represented in Table 2.

In addition, following the methodological assessment, a grade B was allotted to all the trials based on the criteria suggested by the Cochrane Collaboration.

The baseline features of the participants were reported in Table 3. At baseline, patients had an HbA1c ranging from 6.90% to 8.40%. The participants had a mean age ranging from 45.2 to 55.2 years. The percentage of male T2DM patients as well as the average body mass index (BMI) of the participants have been listed in Table 3.

#### 3.3. Fasting blood glucose in patients with type 2 diabetes mellitus assigned to the ginger consumption group

First of all, FBS was compared in patients with T2DM from baseline prior to ginger consumption to follow-up after ginger consumption. The analysis included a total number of 245 participants with T2DM. The results showed no significant difference in FBS with WMD: 1.38, 95% CI: [−0.53–3.30];  $P = .16$  as shown in Figure 2.

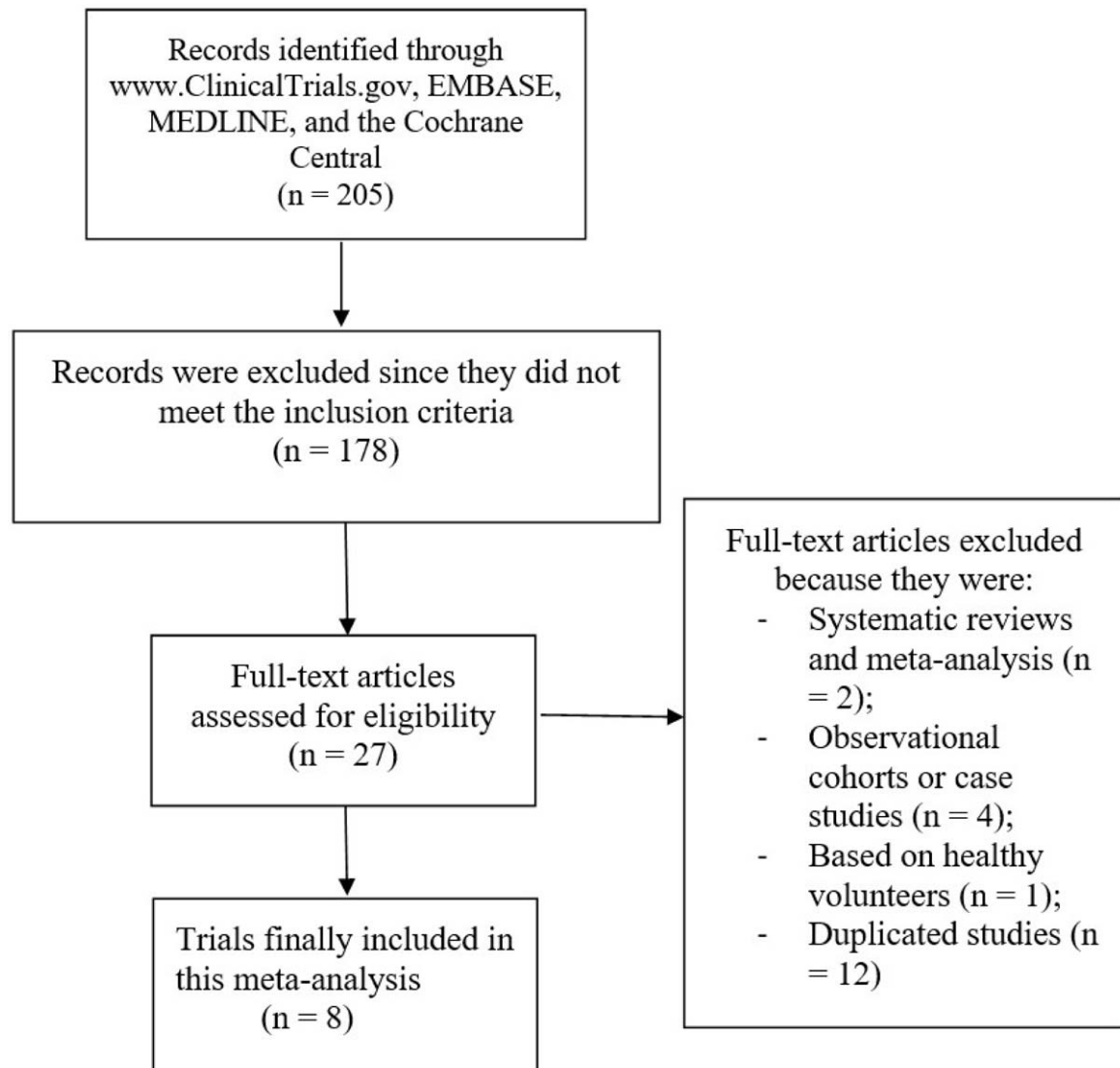


Figure 1. Flow diagram representing the flow of study.

**Table 2**  
General features of the studies.

Trials	Total no of DM patients assigned to ginger group (n)	Total no of DM patients assigned to control group (n)	Type of study	Bias risk grade
Arablou 2014	33	30	Randomized trial	B
Arzati 2017	25	25	Randomized trial	B
Azimi 2015	41	39	Randomized trial	B
Bordia 1997	30	—	Randomized trial	B
Khandouzi 2015	22	19	Randomized trial	B
Khosravi 2014	40	41	Randomized trial	B
Mahluji 2013	32	32	Randomized trial	B
Shidfar 2015	22	23	Randomized trial	B
Total no. of DM patients (n)	245	209		

DM = diabetes mellitus.

**3.4. Fasting blood glucose in patients with type 2 diabetes mellitus assigned to the Control group**

FBS was also assessed in 209 patients with T2DM who did not consume ginger supplement. The result showed no significant difference in FBS at baseline and at follow-up with WMD:  $-0.27$ , 95% CI:  $[-5.09-4.54]$ ;  $P = .91$  as shown in Figure 3.

**3.5. HbA1c in patients with type 2 diabetes mellitus assigned to the ginger consumption group**

HbA1c from baseline to follow-up was also assessed in patients with T2DM who were assigned to the ginger consumption group.

**Table 3**  
Baseline features of the participants.

Trials	Duration of DM, months Exp/Ctrl	HbA1c (%) Exp/Ctrl	Mean age, years Exp/Ctrl	Male gender (%) Exp/Ctrl	BMI, m <sup>2</sup> /kg Exp/Ctrl
Arablou 2014	45.8/48.5	8.40/8.10	52.6/52.0	24.2/23.3	26.9/26.8
Arzati 2017	—	7.30/7.50	51.7/49.6	34.8/27.3	29.9/29.2
Azimi 2015	—	7.94/7.50	55.2/53.6	36.6/38.5	29.05/28.4
Bordia 1997	—	—	—	—	—
Khandouzi 2015	—	7.37/7.30	45.2/47.1	22.7/47.4	—
Khosravi 2014	—	—	49.8/51.1	32.5/43.9	28.1/28.5
Mahluji 2013	—	7.00/6.90	49.2/53.1	43.8/50.0	29.2/29.8
Shidfar 2015	—	7.37/7.39	45.2/47.1	—	29.5/29.3

BMI = body mass index, Ctrl = control group/group not assigned to ginger therapy, DM = diabetes mellitus, Exp = experimental group/group assigned to ginger therapy, HbA1c = glycated hemoglobin.

Two hundred and fifteen participants with T2DM were assessed. The results showed a significantly improved HbA1c from baseline to follow-up with WMD:  $0.46$ , 95% CI:  $[0.09-0.84]$ ;  $P = .02$  as shown in Figure 4.

**3.6. HbA1c in patients with type 2 diabetes mellitus assigned to the Control group**

HbA1c from baseline to follow-up was also assessed in 209 patients with T2DM who were assigned to the control group. Results showed no significant difference in HbA1c within the control group with WMD:  $-0.23$ , 95% CI:  $[-0.60-0.14]$ ;  $P = .22$  as shown in Figure 5.

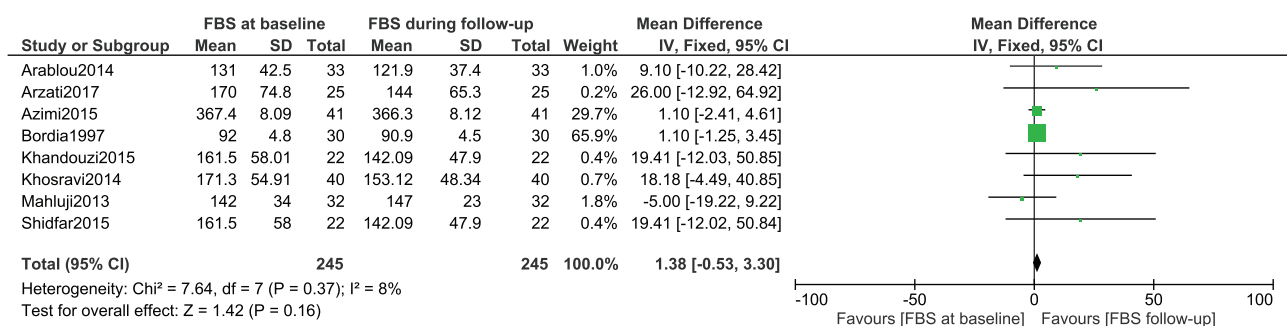


Figure 2. Fasting blood glucose in patients with type 2 diabetes mellitus assigned to the Ginger consumption group.

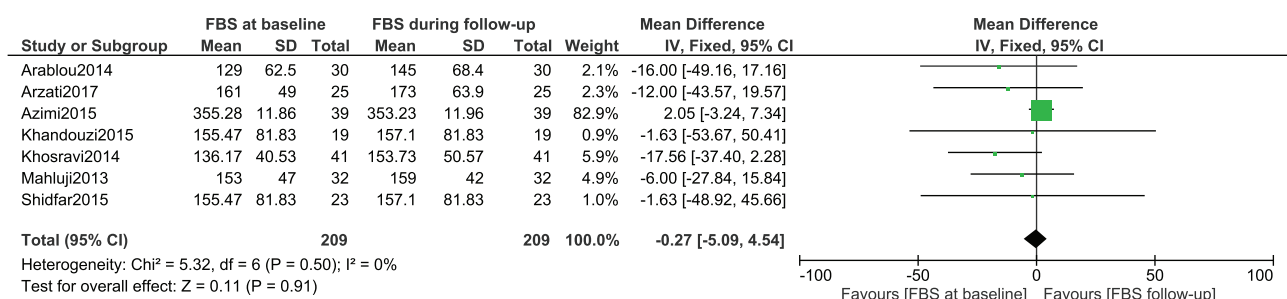


Figure 3. Fasting blood glucose in patients with type 2 diabetes mellitus assigned to the control group.

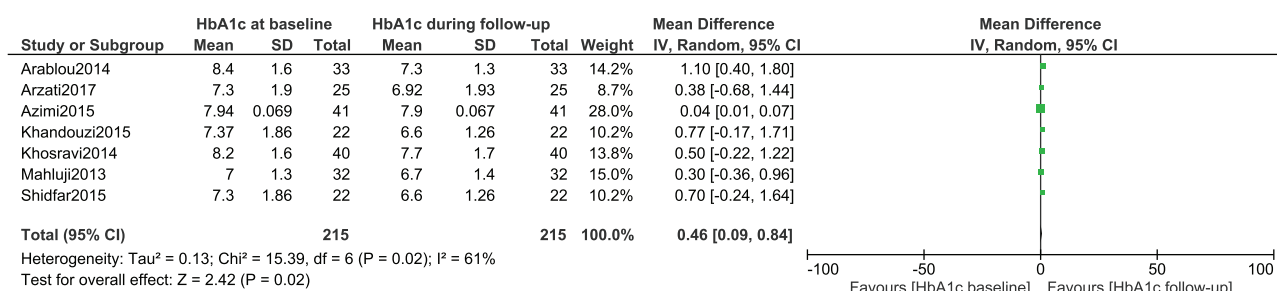


Figure 4. HbA1c in patients with type 2 diabetes mellitus assigned to the Ginger consumption group. HbA1c=glycated haemoglobin.

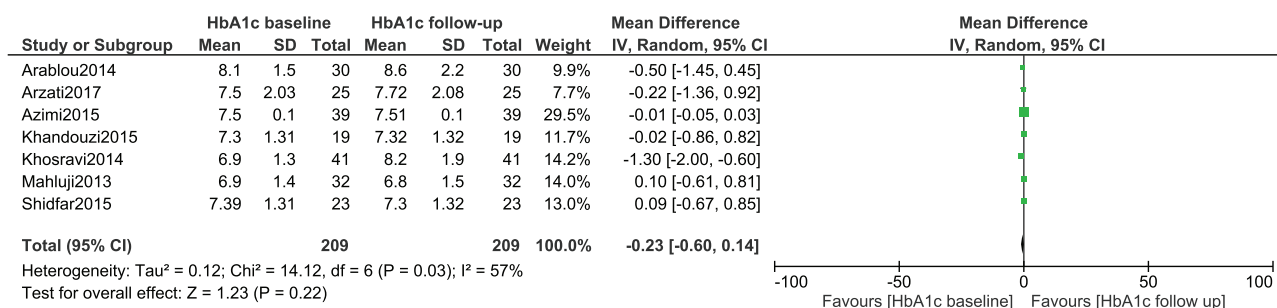


Figure 5. HbA1c in patients with type 2 diabetes mellitus assigned to the control group. HbA1c=glycated haemoglobin.

#### 4. Discussion

The results of this meta-analysis showed with evidence, the benefits of ginger intake to control blood sugar level in patients with T2DM, especially during the long term. Ginger consumption was not associated with increased FBS. However, HbA1c significantly improved from baseline to follow-up in these patients with T2DM.

Another systematic review and meta-analysis showed beneficial effects of ginger consumption in patients with T2DM.<sup>[29]</sup> The analysis showed that ginger subsequently reduced FBS and significantly improved HbA1c in these patients with T2DM which was partly in support of this current analysis. However, their analysis was not strictly based on diabetic control and our analysis was better in the way that it included even more trials to assess the corresponding endpoints as compared to the previous meta-analysis.

Another study showed that consumption of ginger (1000 mg daily) might reduce plasma fasting sugar thus preventing complications such as hyper insulinemia, dyslipidemia, peritoneal membrane fibrosis, and cardiovascular disease in patients on peritoneal dialysis.<sup>[30]</sup> Ginger also has beneficial effects on obesity and metabolic syndrome.

Ginger has antidiabetic properties and studies have shown ginger to control hyperinsulinemia in patients with T2DM.<sup>[31]</sup> Ginger also has potential effects in preventing or reducing diabetic complications such as micro-vascular retinopathy.<sup>[32]</sup> Additionally, ginger has shown to protect the liver, kidney, and neural system complications in patients with T2DM. The mechanisms which are involved deal with insulin release and increased plus accelerated carbohydrate and lipid metabolism.<sup>[33]</sup>

Furthermore, ginger consumption was associated with other potential benefits especially in patients with chronic diseases.<sup>[34]</sup>

Apart from T2DM, ginger was shown to be effective in patients with hypertension and coronary artery disease.<sup>[35]</sup> This natural traditional medicine could even act as a primary preventive measure to these chronic disorders.

#### 4.1. Limitations

The restricted total number of participants could be a major limitation of this study. Secondly, follow-up time period varied from 8 to 12 weeks, even if to a lesser extent, this could have influenced the results. In addition, the duration of disease was unknown in most of the studies. It is also not known whether the participants were previously or recently diagnosed with T2DM. The daily amount of ginger which were different in different trials might also be a limiting factor in this study. There was also no major mention about the consumption of western medicine which might have influenced the final outcomes.

#### 5. Conclusion

This analysis involving patients with T2DM showed no significant difference in FBS with ginger consumption. However, dietary ginger significantly improved HbA1c from baseline to follow-up showing that this natural medicine might have an impact on glucose control over a longer period of time in patients with T2DM.

#### Acknowledgment

All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.



## Author contributions

Fang-yan Huang, Ting Deng, Lian-xin Meng, and Xin-ling Ma were responsible for the conception and design, acquisition of data, analysis and interpretation of data, drafting the initial manuscript and revising it critically for important intellectual content. Fang-yan Huang wrote this manuscript.

**Conceptualization:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Data curation:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Formal analysis:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Funding acquisition:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Investigation:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Methodology:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Project administration:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Resources:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Software:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Supervision:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Validation:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Visualization:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Writing - Original Draft:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

**Writing - Review & Editing:** Fang-yan Huang, Ting Deng, Lian-xin Meng, Xin-ling Ma.

## References

- Li FF, Jiang LL, Yan RN, et al. Effects of saxagliptin add-on therapy to insulin on blood glycemic fluctuations in patients with type 2 diabetes: a randomized, control, open-labeled trial. *Medicine (Baltimore)* 2016;95:e5229.
- Fujihara K, Igarashi R, Matsunaga S, et al. Comparison of baseline characteristics and clinical course in Japanese patients with type 2 diabetes among whom different types of oral hypoglycemic agents were chosen by diabetesspecialists as initial monotherapy (JDDM 42). *Medicine (Baltimore)* 2017;96:e6122.
- Xiong W, Xiao MY, Zhang M, et al. Efficacy and safety of canagliflozin in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. *Medicine (Baltimore)* 2016;95:e5473.
- Ko SH, Kim DJ, Park JH, et al. Task Force Team for Diabetes Fact Sheet of the Korean Diabetes Association. Trends of antidiabetic drug use in adult type 2 diabetes in Korea in 2002-2013: Nation wide population-based cohort study. *Medicine (Baltimore)* 2016;95:e4018.
- Dai X, Luo ZC, Zhai L, et al. Adverse drug events associated with low-dose (10 mg) versus high-dose (25 mg) empagliflozin in patients treated for type 2 diabetes mellitus: a systematic review and meta-analysis of randomized controlled trials. *Diabetes Ther* 2018;9:753-70.
- Wu CT, Tsai YT, Lin JG, et al. Chinese herbal products and the reduction of risk of breast cancer among females with type 2 diabetes in Taiwan: a case-control study. *Medicine (Baltimore)* 2018;97:e11600.
- Kasuli EG. Are alternative supplements effective treatment for diabetes mellitus? *Nutr Clin Pract* 2011;26:352-5.
- Lee AL, Chen BC, Mou CH, et al. Association of traditional Chinese medicine therapy and the risk of vascular complications in patients with type II diabetes mellitus: a nationwide, retrospective, Taiwanese-Registry, Cohort Study. *Medicine (Baltimore)* 2016;95:e2536.
- Lin SK, Tsai YT, Lo PC, et al. Traditional Chinese medicine therapy decreases the pneumonia risk in patients with dementia. *Medicine (Baltimore)* 2016;95:e4917.
- Zhao X, Zhen Z, Guo J, et al. Assessment of the reporting quality of placebo-controlled randomized trials on the treatment of type 2 diabetes with traditional Chinese medicine in Mainland China: a PRISMA-compliant systematic review. *Medicine (Baltimore)* 2016;95:e2522.
- Gui QF, Xu ZR, Xu KY, et al. The efficacy of ginseng-related therapies in type 2 diabetes mellitus: an updated systematic review and meta-analysis. *Medicine (Baltimore)* 2016;95:e2584.
- Wong YC. Need of integrated dietary therapy for persons with diabetes mellitus and "unhealthy" body constitution presentations. *J Integr Med* 2016;14:255-68.
- Wang WJ, Zhang T. Integration of traditional Chinese medicine and Western medicine in the era of precision medicine. *J Integr Med* 2017;15:1-7.
- Bi X, Lim J, Henry CJ. Spices in the management of diabetes mellitus. *Food Chem* 2017;217:281-93.
- Wei JP, Wang QH, Zheng HJ, et al. Research progress on non-drug treatment for blood glucose control of type 2 diabetes mellitus. *Chin J Integr Med* 2018;24:723-7.
- Chakraborty R, Roy S, Mandal V. Assessment of traditional knowledge of the antidiabetic plants of Darjeeling and Sikkim Himalayas in the context of recent phytochemical and pharmacological advances. *J Integr Med* 2016;14:336-58.
- Nicoll R, Henein MY. Ginger (*Zingiber officinale* Roscoe): a hot remedy for cardiovascular disease? *Int J Cardiol* 2009;131:408-9.
- Li Y, Tran VH, Duke CC, et al. Preventive and protective properties of *Zingiber officinale* (Ginger) in diabetes mellitus, diabetic complications, and associated lipid and other metabolic disorders: a brief review. *Evid Based Complement Alternat Med* 2012;2012:516870.
- Higgins JP, Altman DG. Assessing risk of bias in included studies. *Cochrane Handbook for Systematic Reviews of Interventions* 2008; Wiley, 187-241.
- Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;339:b2700.
- Arablou T, Aryaiean N, Valizadeh M, et al. The effect of ginger consumption on glycemic status, lipid profile and some inflammatory markers in patients with type 2 diabetes mellitus. *Int J Food Sci Nutr* 2014;65:515-20.
- Makhdoomi Arzati M, Mohammadzadeh Honarvar N, Saedisomeolia A, et al. The effects of ginger on fasting blood sugar, hemoglobin A1c, and lipid profiles in patients with type 2 diabetes. *Int J Endocrinol Metab* 2017;15:e57927.
- Azimi P, Ghiasvand R, Feizi A, et al. Effects of cinnamon, cardamom, saffron, and ginger consumption on markers of glycemic control, lipid profile, oxidative stress, and inflammation in type 2 diabetes patients. *Rev Diabet Stud* 2014;11:258-66. Fall-Winter.
- Bordia A, Verma SK, Srivastava KC. Effect of ginger (*Zingiber officinale* Rosc.) and fenugreek (*Trigonella foenumgraecum* L.) on bloodlipids, blood sugar and platelet aggregation in patients with coronary artery disease. *Prostaglandins Leukot Essent Fatty Acids* 1997;56:379-84.
- Khandouzi N, Shidfar F, Rajab A, et al. The effects of ginger on fasting blood sugar, hemoglobin 1c, apolipoprotein B, apolipoprotein A-I and malondialdehyde in type 2 diabetic patients. *Iran J Pharm Res* 2015;14:131-40. Winter.
- Mozaffari-Khosravi H, Talaei B, Jalali BA, et al. The effect of ginger powder supplementation on insulin resistance and glycemic indices in patients with type 2 diabetes: a randomized, double-blind, placebo-controlled trial. *Complement Ther Med* 2014;22:9-16.
- Mahluji S, Attari VE, Mobasser M, et al. Effects of ginger (*Zingiber officinale*) on plasma glucose level, HbA1c and insulin sensitivity in type 2 diabetic patients. *Int J Food Sci Nutr* 2013;64:682-6.
- Shidfar F, Rajab A, Rahideh T, et al. The effect of ginger (*Zingiber officinale*) on glycemic markers in patients with type 2 diabetes. *J Complement Integr Med* 2015;12:165-70.
- Zhu J, Chen H, Song Z, et al. Effects of ginger (*Zingiber officinale* Roscoe) on type 2 diabetes mellitus and components of the metabolic syndrome: a systematic review and meta-analysis of randomized controlled trials. *Evid Based Complement Alternat Med* 2018;2018:5692962.
- Imani H, Tabibi H, Najafi I, et al. Effects of ginger on serum glucose, advanced glycation end products, and inflammation in peritoneal dialysis patients. *Nutrition* 2015;31:703-7.
- Abdulrazak A, Tanko Y, Mohammed A, et al. Effects of clove and fermented ginger on blood glucose, leptin, insulin and insulin receptor levels in high fat diet induced type 2 diabetic rabbits. *Niger J Physiol Sci* 2018;33:89-93.

- [32] Dongare S, Gupta SK, Mathur R, et al. *Zingiber officinale* attenuates retinal microvascular changes in diabetic rats via anti-inflammatory and antiangiogenic mechanisms. *Mol Vis* 2016;22:599–609.
- [33] Abdulrazaq NB, Cho MM, Win NN, et al. Beneficial effects of ginger (*Zingiber officinale*) on carbohydrate metabolism in streptozotocin-induced diabetic rats. *Br J Nutr* 2012;108:1194–201.
- [34] Wang Y, Yu H, Zhang X, et al. Evaluation of daily ginger consumption for the prevention of chronic diseases in adults: a cross-sectional study. *Nutrition* 2017;36:79–84.
- [35] Subbaiah GV, Mallikarjuna K, Shanmugam B, et al. Ginger treatment ameliorates alcohol-induced myocardial damage by suppression of hyperlipidemia and cardiac biomarkers in rats. *Pharmacogn Mag* 2017;13(suppl 1):S69–75.