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Chamomile tea improves glycemic indices and antioxidants status in patients with type 2 diabetes mellitus

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ABSTRACT

Objectives: Oxidative stress is a major factor in the pathogenesis of diabetes complications. The objectives were to investigate the effects of chamomile tea consumption on glycemic control and antioxidant status in subjects with type 2 diabetes mellitus (T2 DM).
Methods: This single-blind randomized controlled clinical trial was conducted on 64 subjects with T2 DM (males and females) ages 30 to 60 y. The intervention group (n = 32) consumed chamomile tea (3 g/150 mL hot water) 3 times per day immediately after meals for 8 wk. The control group (n = 32) followed a water regimen for same intervention period. Fasting blood samples, anthropometric measurements, and 3-d, 24-h dietary recalls were collected at the baseline and at the end of the trial. Data were analyzed by independent *t* test, paired *t* test, and analysis of covariance.
Results: Chamomile tea significantly decreased concentration of glycosylated hemoglobin, serum insulin levels, homeostatic model assessment for insulin resistance, and serum malondialdehyde, compared with control group (all $P < 0.05$). Total antioxidant capacity, superoxide dismutase, glutathione peroxidase, and catalase activities were significantly increased by 6.81%, 26.16 %, 36.71 % and 45.06% respectively in chamomile group compared with these variables in control group at the end of the intervention (all $P < 0.05$).
Conclusions: Short term intake of chamomile tea has beneficial effects on glycemic control and antioxidant status in patients with T2 DM. A larger sample population and a longer intervention period may be required to show significant clinical improvements.

Introduction

Type 2 diabetes mellitus (T2 DM) is a chronic metabolic disease characterized by hyperglycemia. It has significant effects on health, quality of life, and health care systems. The International Diabetes Federation (IDF) estimates that 439 million people, 7.7% of the world population, will suffer from diabetes by 2030 [1]. Chronic hyperglycemia causes complications of diabetes, such as heart disease, retinopathy, renal disease, and neuropathy [2].

Oxidative stress associated with hyperglycemia is now recognized as the driving force for the development of diabetic complications [3]. Oxidative stress in diabetes is related to activation of the polyol pathway, formation of advanced glycation end products, activation of protein kinase C, and subsequent formation of reactive oxygen species [4–8]. In the absence of a suitable condensation by antioxidant defense system, enhancement of oxidative stress leads to activation of stress-sensitive intracellular signaling pathways and the formation of gene products that cause cellular damage [9–12].

Apart from currently available therapeutic options, like oral hypoglycemic drugs and insulin therapy, which have limitations, many traditional plant medicines have been used in the treatment of diabetes [13]. Plants apparently provide effective remedies, produce only minimal or no side effects in clinical

MR was the main study investigator; MZ worked as an investigator on the study and contributed to the manuscript; MAJ worked on the statistical analysis plans and analyses the results.

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experiment, and are relatively low cost, as compared to oral synthetic hypoglycemic drugs [14].

German chamomile (Matricariachamomilla L.) is an herbaceous plant that is native to Europe and Western Asia [15]. The consumption of chamomile as tea is rated as more than one million cups per day [16]. Current studies have demonstrated its antioxidant, antiparasitic, antiaging, and anticancer properties, supporting its traditional use for treating various human ailments [17–19]. Sesquiterpenic compounds such as α-bisabolol, bisabolol oxides A and B, chamazulene and farnesene, and phenolic compounds, namely flavonoids including apigenin, quercetin, patuletin and luteolin, and their glucosides, as well as coumarins are considered to be the major bioactive compounds of this plant [20].

Antihyperglycemic and antioxidant activity of chamomile extracts have been demonstrated in experimental studies [21–23]. Cemek et al. indicated that treatment with different doses of chamomile ethanolic extract significantly lowered postprandial hyperglycemia and oxidative stress, and augmented the antioxidant system in streptozotocin (STZ)-induced diabetic rats [21]. In the study by Kholoud and Manal, chamomile aqueous extract effectively decreased blood glucose levels and oxidative stress in STZ-induced diabetic rats [22]. Namjooyan et al. determined that antioxidant activity of chamomile extract reduced the incidence of diabetic embryopathy in the STZ-induced diabetic rat model [23].

Although some experimental studies have reported effects of different extracts of chamomile on glycemic status and oxidative stress in diabetes, its possible effects on metabolic and antioxidant status of patients with diabetes have not been investigated. We hypothesized that chamomile tea consumption would ameliorate glycemic and antioxidant indices in subjects with T2 DM. To test these hypotheses, we initiated a study to evaluate the effects of chamomile tea on glycemic control (serum levels of glucose, glycosylated hemoglobin [HbA1 c], insulin, and homeostasis model assessment-insulin resistance [HOMA-IR]), and antioxidant status (total antioxidant capacity [TAC], activity of superoxide dismutase [SOD] and glutathione peroxidase [GSH-Px], and malondialdehyde [MDA]) in patients with T2 DM.

Materials and methods

Sixty-four patients with type 2 diabetes (male & female) ages 30 to 60 y with a body mass index (BMI) lower than 37 kg/m^2 were recruited for this study from the endocrinology clinic, Imam Hossien Hospital in Tehran, Iran from March 2013 to June 2013. Diagnosis of T2 DM was assessed at least six month before our examination. Exclusion criteria included insulin treatment, smoking, alcoholism, consumption of any dietary supplements, green tea, and other herbal infusion in the past 3 mo or during the study. A history of diseases including liver, kidney and cardiovascular diseases, thyroid disorders, gastrointestinal problems, cholesterol-lowering or antihypertension treatment, using corticosteroids, cyclosporine, non-steroidal antiinflammatory or immunosuppressive drugs, warfarin and antiepileptic medications, pregnancy or breast-feeding, following a specific diet and regular exercise (>2 weeks), and allergy to plants of ragweed species, and having jobs that need high level of consciousness, was taken for each subject.

The study consisted of a single-blinded randomized, controlled clinical trial with treatment and control groups running in parallel for a period of 8 wk. Ethical Committee of Tabriz University of Medical Sciences approved the study protocol, and was registered on the Iranian Registry of Clinical Trials website (http://www.irct.ir, identifier: IRCT2013012712299 N1). The study was conducted in accordance with the guidelines of the Declaration of Helsinki principles. All subjects gave written informed consent before clinical trial enrolment.

The sample size was determined based on the primary information obtained from the study by Kato et al. for blood glucose [24]. Considering 95% confidence interval and 80% power, and a change of blood glucose in 8 wk as primary outcome of the study, the sample size was computed to be 23 per group. This number was increased to 32 per group to accommodate the anticipated dropout rate. The participants were randomly allocated in two groups using a block randomization procedure (of size 4) with matched subjects in each block based on sex, age, and body mass index (BMI). The random sequence was generated using random allocation software by the statistician for the study. The endocrinologist randomly assigned participants to an intervention or control group. Whereas patients and the endocrinologist allocated to the intervention group were aware of the allocated group, outcome assessors and the statistician were blinded to the allocation.

A general questionnaire was completed for each subject. Body weight was measured using a scale (Seca, Hamburg, Germany), without shoes and wearing light clothing. Height was measured using a mounted tape without shoes. BMI was calculated as the weight in kilogram divided by the height in meters squared. Information about daily energy and macronutrient intakes were obtained by 24-h recall method for 3 d, including 2 d during the week and 1 during the weekend. A three day average for energy and macronutrient intakes of all subjects were analyzed by Nutritionist 4 software (First Databank Inc., San Bruno, CA).

Chamomile was obtained as homogenous chamomile tea bags (finished product) from the Iranian Institute of medicinal plants, Karaj Iran. The tea bag, containing approximately 3 g of chamomile tea, was manufactured on March 2013. These tea bags are a commercially available product. The intervention group (n = 32) consumed one cup of chamomile tea infusate (1 chamomile tea bag infused for 10 min in 150 mL hot water without milk or sugar) three times a day immediately after meals (breakfast, lunch, and dinner) for 8 wk [24,25]. The control group (n = 32) consumed an equivalent volume of warm water during the 8-wk period (Fig. 1). Subjects were asked to keep a record of all beverages consumed during the clinical trial and maintain their usual dietary intake and physical activity and to avoid any changes in medication, if possible. The compliance of the volunteers for the study protocol was monitored with telephone interviews once a week and counting returned tea bags in person every 2 wk.

Blood sampling and biochemical assays

Venous blood samples (5 mL) from each subject were collected between 07:00 to 09:00 h after an overnight fast at the beginning of trial. Two mL of whole blood were collected into tube contained ethylene-diamine-tetra acetic acid to measure the blood levels of HbA1 c. The serum samples were separated from whole blood by centrifugation at 3500 rpm for 10 min (Avanti J-25, Beckman, Brea, CA, USA). The serum and whole blood samples were frozen immediately at −70°C.

Serum glucose was measured using the standard enzymatic methods with commercially available Pars Azmun kit (Karaj, Iran). HbA1 c was measured in the whole blood by cation exchange chromatography with a Nycocard HbA1C kit (Oslo, Norway). Serum insulin level was measured by ELISA method using Monobind kit (Monobind Inc, Lake Forest, CA, USA) and insulin resistance was determined by HOMA index with formula: HOMA-IR = fasting insulin (μU/mL) × fasting glucose (mg/dL)/405 [26]. Serum total cholesterol, triacylglycerol, and high-density lipoprotein cholesterol were measured using the standard enzymatic methods by Pars Azmun kits (Pars Azmun Co., Kiraj, Iran). Low-density lipoprotein cholesterol concentration was determined by the Friedewald formula [27]. Measurement of TAC in serum and SOD and GSH-Px in whole blood was performed by using the colorimetric method with commercial kits (TAC, RANDOX kits; SOD, RANSOD kits; and GSH-Px, RAN–SEL kits; UK) [28–30]. The serum MDA level was estimated by using a reaction with thiobarbituric acid as a thiobarbituric acid reactive substance to produce a pink colored complex. Next, its fluorescence intensity was measured at 547 nm with excitation at 525 nm by a spectrofluorimeter (model SFM 25 A; Kontron, Milan, Italy) [31]. Catalase (CAT) activity was measured by using the method described by Aebi [32].

All anthropometric, dietary intakes, blood sampling, and biochemical measurements were assessed again at the end of intervention period in both groups.

Statistical analyses

Data were analyzed using SPSS version 16 (SPSS Inc., Chicago, IL, USA) and the results are expressed as means ± SD. The normal distribution of variables was tested and confirmed by Kolmogorov-Smirnov test. The baseline measurements and dietary intakes of subjects in two groups were compared using independent samples *t* test and chi-square test for quantitative and qualitative variables respectively. Analysis of covariance (ANCOVA) was used to identify any differences between the two groups at the end of study, adjusting for baseline values and covariates. The changes in anthropometric measurements, energy and nutrient intakes, serum levels of glucose, HbA1 c, insulin, HOMA-IR, TAC, SOD, GSH-Px, CAT, and MDA levels between the beginning and end of the study were compared by paired samples *t* test. The percentage of changes in variables after intervention was determined with the formula: [(after values–before values)/before values] × 100. Results with $P < 0.05$ were considered as statistically significant.

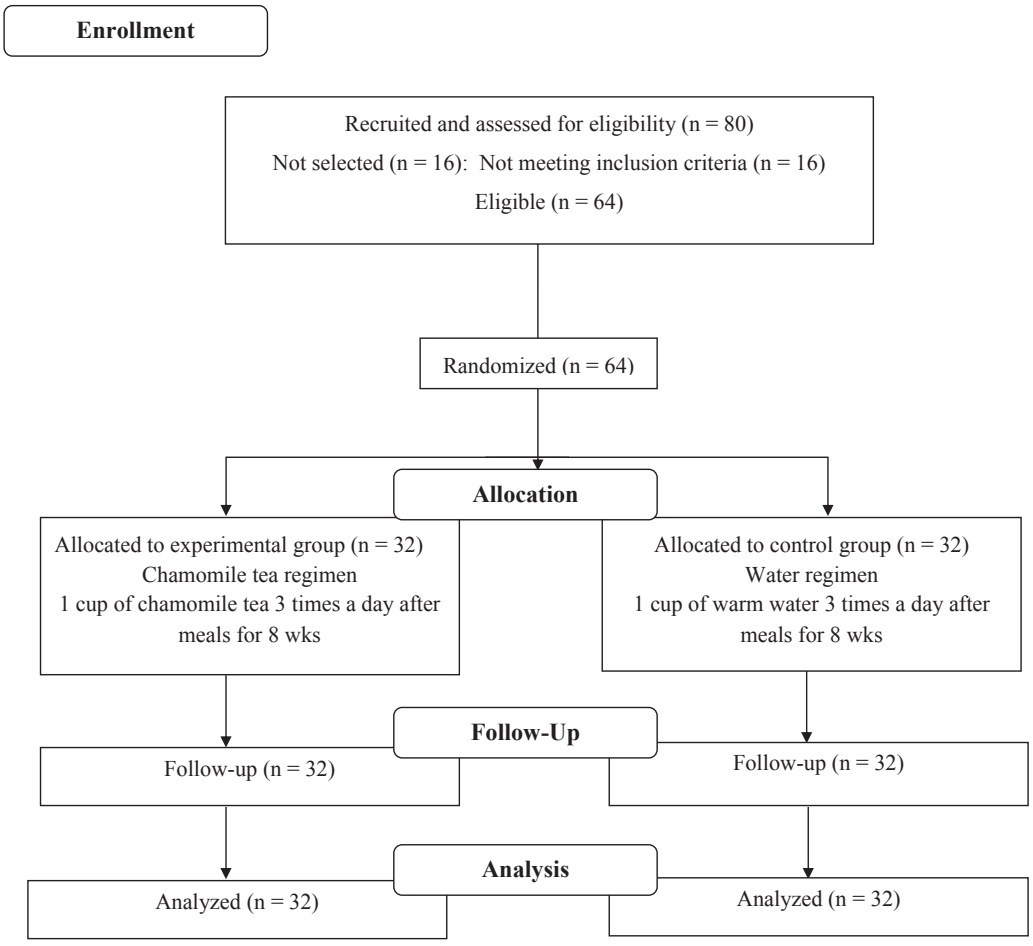

Fig. 1. Flow diagram showing trial profile and study design.

Results

All of the patients (32 patients in chamomile tea group and 32 patients in placebo group) completed the study (Fig. 1). Compliance was more than 97% of the tea bags in a prescribed manner being consumed during the study period. Participants did not report any adverse effects or symptoms with the chamomile tea consumption during the study.

Anthropometric characteristics and dietary intakes of participants at the beginning and end of the study are shown in Table 1. There were no significant differences between or within groups in weight and BMI at the beginning of the study and after 8 wk of intervention. No significant differences in energy and other dietary intakes were observed between two groups at baseline. Total energy and nutrient intakes also did not change significantly in any of the groups during the study.

Figure 2 (A-D) illustrates changes in serum levels of glucose, HbA1 c, insulin, and HOMA-IR of chamomile tea group and control group during 8-wk period of study. Levels of HbA1 c were not different between two groups at baseline. Significant differences were seen between the two groups in serum levels of glucose, insulin and HOMA-IR at baseline. As shown in Figure 2 (B-D), significant differences were seen between two studied groups in HbA1 c, HOMA-IR, and serum insulin levels at the end of the study adjusted for baseline values, duration of diabetes, intake of oral hypoglycemic agents, and changes of weight and calorie during the study ($P < 0.05$). Serum glucose levels were in the range of 102 to 332 and 90 to 368 mg/dL in the chamomile tea group, and 111 to 260 and 122 to 238 mg/dL in control group, before and after study, respectively. Changes in serum glucose levels ($P = 0.08$) was not significant (Fig. 2A). Serum levels of glucose, insulin, HbA1 c, and HOMA-IR significantly decreased in the intervention group by 11.09%, $P = 0.004$ (versus 5.1%, $P = 0.28$ increase in control group), 32.59%, $P < 0.001$ (versus 2.5%, $P < 0.001$ increase in control group), 5.01%, $P < 0.001$ (versus 0.78%, $P = 0.84$ increase in control group) and 39.76%, $P < 0.001$ (versus 7.79%, $P = 0.06$ increase in control group), respectively at the end of the study in comparison to baseline values (data not shown). Results of chamomile tea consumption on lipid profile in our study subjects were published in advanced [27]. Based on the findings, serum levels of triacylglycerol, total cholesterol, and low-density lipoprotein cholesterol significantly decreased in the intervention group by 18.35% (versus 5.87% increase in control group), 9.56% (versus 2.97% increase in control group) and 8.85% (versus 5.68% increase in control group) at the end of the study in comparison to baseline values. Levels of serum high-density lipoprotein cholesterol remained unchanged in both groups at the end of study (data not shown).

TAC, enzymatic antioxidants, and MDA levels of subjects at baseline and after 8 wk intervention are shown in Table 2. Significant differences were seen between the two groups in

Table 1
General characteristics and dietary intakes of diabetic patients at baseline and after 8 wk of intervention

Variable	Measurement period	Chamomile tea group (n = 32)	Control group (n = 32)
Age (y)	Baseline	50.19 ± 7.08	51.97 ± 6.42
Height (cm)	Baseline	160.00 ± 6.50	162.12 ± 6.34
Weight (kg)	Baseline	76.00 ± 6.71	79.65 ± 6.62
	After intervention	74.53 ± 6.48	79.87 ± 6.80
BMI (kg/m^2)	Baseline	29.48 ± 2.79	30.38 ± 2.6
	After intervention	29.12 ± 3.61	30.48 ± 2.72
Metformin 500 mg, tablets/d	Baseline	2.47 ± 0.77	2.17 ± 0.75
Glibenclamide 5 mg, tablets/d	Baseline	1.55 ± 0.51	1.59 ± 0.50
Energy (kcal/d)	Baseline	1988.2 ± 201.2	1958.3 ± 217.1
	After intervention	2011 ± 221	1979.1 ± 248.00
Carbohydrate (g/d)	Baseline	298.20 ± 40.90	298.8 ± 53.6
	After intervention	303.24 ± 38.22	293.01 ± 54.78
Protein (g/d)	Baseline	74.43 ± 15.82	74.79 ± 14.11
	After intervention	76.32 ± 13.06	80.65 ± 14.49
Total Fat (g/d)	Baseline	57.6 ± 11.8	53.3 ± 10.4
	After intervention	57.51 ± 15.26	55.84 ± 11.89
Vitamin C (mg)	Baseline	130.21 ± 50.51	140.86 ± 63.94
	After intervention	128.86 ± 59.16	138.22 ± 54.55
Vitamin E (mg)	Baseline	11.61 ± 7.28	11.27 ± 7.60
	After intervention	10.35 ± 6.84	11.32 ± 7.13
Zinc (mg)	Baseline	8.88 ± 3.54	9.13 ± 3.14
	After intervention	9.11 ± 2.21	9.76 ± 2.19

BMI, body mass index
The results are described as means ± Standard Deviation (SD)

serum levels of TAC, MDA, and activity of SOD and GSH-Px at baseline. Levels of CAT were not different between two groups at baseline. Results of ANCOVA showed statistically significant differences between two studied groups in serum TAC ($P = 0.04$), MDA ($P < 0.001$), and activities of CAT ($P < 0.001$), GSH-Px ($P = 0.01$), and SOD ($P = 0.001$) at the end of the study, adjusted for baseline values, duration of diabetes and changes of weight and calorie during the study. Consumption of chamomile tea increased levels of TAC by 6.81%, SOD by 26.16%, CAT by 45.06%, GSH-Px by 36.71%, and decreased serum levels of MDA by 33.23% compared with these variables in control group. As shown in Table 2, serum levels of TAC and activities of CAT, GSH-Px, and SOD significantly increased in the chamomile tea group (by 15.18%, 36.52%, 49.52%, and 32.5%) at the end of the study. Significant decrease in serum levels of MDA by 45.8% was obtained in chamomile tea group over the 8 wk in comparison to baseline values.

Discussion

In folk medicine, chamomile tea has been used for antiinflammation, antioxidant action, irritation, and pain relief [15,33]. To our knowledge, only few studies in animals showed antidiabetic and antioxidative potential effects of alcoholic or aqueous extract of chamomile. Based on our literature review, this trial is the first report about the effects of chamomile tea consumption on glycemic indices and antioxidant status in patients with diabetes.

Our findings indicate that drinking chamomile tea significantly decreased serum level of glucose in the intervention group compared to its baseline values and decreased levels of HbA1 c compared to control group. These results are agreement with findings of previous studies in animals [21,22,24,34,35]. Kato et al. reported that aqueous extracts of chamomile (500 mg/kg/d orally) and its major components reduced blood glucose levels in STZ-induced diabetic rats [24]. Eddouks et al. indicated that administration of aqueous extracts of chamomile (20 mg/kg/d) decreased blood glucose levels after 2 wk in normal and STZ-induced diabetic rats [34]. Kholoud and Manal investigated the effects of water extract of chamomile in STZ-induced diabetic rats, and observed significant decrease in blood

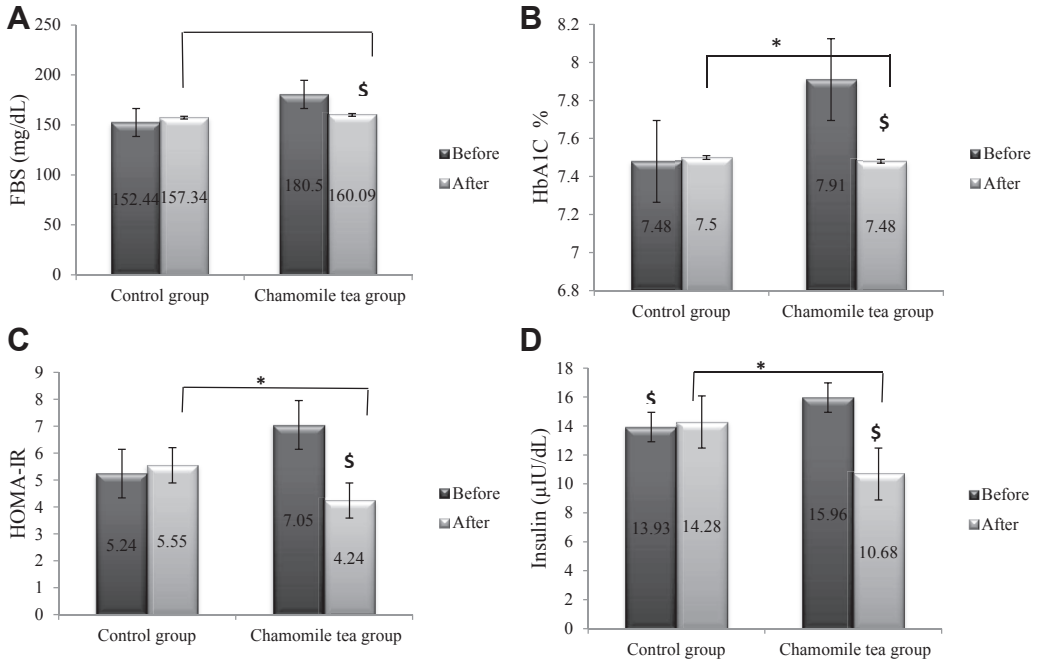

Fig. 2. Effects of chamomile tea on (A) fasting blood sugar, (B) glycosylated hemoglobin, (C) homeostasis model assessment-insulin resistance (HOMA-IR), and (D) serum insulin. Data were present as means ± SE for 32 diabetic patients in each group. $^{\dagger}P < 0.05$ for within group comparisons (paired sample *t* test); $^{*}P < 0.05$ for between group comparisons (ANCOVA adjusted for baseline value, intake of oral hypoglycemic agents, and changes of weight and calorie during the study and duration of diabetes).

Table 2
Biochemical parameters of diabetic patients at baseline and after 8 wk of intervention

Variable	Measurement period	Chamomile tea group (n = 32)	Control group (n = 32)	MDA (95% CI), *P*-value
TAC (mmol/L)	Baseline	1.23 ± 0.23	1.59 ± 0.57	0.358 (0.13, 0.57), 0.002*
	After intervention	1.41 ± 0.36	1.32 ± 0.26	−0.17 (−0.35, 0.01), 0.04‡
	MDA (95% CI), *P*-value†	0.18 (0.09, 0.27), <0.001	−0.26 (−0.45, −0.08), 0.007	
SOD (U/mg Hb)	Baseline	1215.04 ± 292.57	1452.35 ± 302.4	237.3 (88.61, 385.99), 0.002*
	After intervention	1559 ± 392.19	1235.64 ± 328.06	−388.76 (−600.83, −176.69), 0/001‡
	MDA (95% CI), *P*-value†	344.92 (211.24, 478.6), <0.001	−216.7 (−346.95, −86.45), 0.002	
GSH-Px (U/g Hb)	Baseline	30.12 ± 8.85	37.32 ± 8.51	−23.83 (−33.07, −14.59), <0.001*
	After intervention	41.74 ± 14.65	30.53 ± 9.99	−10.07 (−18.42, −1.72), 0.01‡
	MDA (95% CI), *P*-value†	11.62 (5.82, 17.43), <0.001	−6.78 (−10.89, −2.67), 0.002	
Catalase (U/g Hb)	Baseline	61.42 ± 24.5	67.45 ± 23.47	6.02 (−5.96, 18.01), 0.319*
	After intervention	76.71 ± 23.12	52.88 ± 12.17	−29.09 (−39.91, −18.26), <0.001‡
	MDA (95% CI), *P*-value†	15.28 (5.31, 25.26), 0.004	−14.56 (−22.59, −6.54), 0.001	
MDA (nmol/mL)	Baseline	4.29 ± 1.72	2.95 ± 1.66	−1.34 (−2.18, −0.49), 0.002*
	After intervention	2.27 ± 1.2	3.4 ± 1.72	2.07 (1.29, 2.84), <0.001‡
	MDA (95% CI), *P*-value†	−2.02 (−2.46, −1.58), <0.001	0.45 (−0.08, 0.98), 0.098	

MDA, malondialdehyde; TAC, total antioxidant status; SOD, superoxide dismutase; GSH-Px, glutathione peroxidase; CI, confidence interval
The results are described as means ± SD
* MD (95% CI), *P*-value is reported based on the analysis of independent sample *t* test.
† MD (95% CI), *P*-value is reported based on the analysis of paired sample *t* test.
‡ MD (95% CI), *P*-value is reported based on the analysis of covariance.

glucose after 21 d with 100 mg/kg/d extract administered orally [22]. Other studies also showed significant effects of ethanolic extract of chamomile by different dosages and period in diabetic rats [21,35]. Also, we previously reported that chamomile tea improved lipid profile indexes [27].

It was suggested that antihyperglycemic activity of chamomile might be due to stimulation of peripheral glucose, especially in muscle and adipose tissue, and/or inhibition of key enzymes involved in the gluconeogenesis and glycogenolysis pathways. Modulation of PPARs and other factors by chamomile extract might be another related mechanism(s). In addition, esculetin and quercetin, two major constituents of chamomile, inhibit intestinal α-glucosidase activities and decrease blood glucose in STZ-diabetic rats [24]. Luteolin and quercetin were shown to inhibit hepatic glycogen phosphorylase and increase liver glycogen content [24]. Chlorogenic acid, a phenolic acid present in chamomile flowers, may slow down carbohydrate absorption by inhibiting intestinal glucose transport [36].

Exposure to hyperglycemia for a long time induces oxidative stress and decreases capacities of the endogenous antioxidant defense system, which leads to production of several reducing sugars [37]. Reactive oxygen species react with lipids, which causes peroxidative changes that result in elevated lipid peroxidation products such as MDA [38]. TAC is an indicator of the overall protective effect of antioxidants in body fluids, on cell membranes, and other components of cells against oxidative injury [39]. SOD, GSH-Px, and CAT are nonenzymatic antioxidants which play a role in the repair of free radicals exposed to biological damage. SOD catalyzes the conversion of superoxide radical to hydrogen peroxide and molecular oxygen. CAT promotes the reduction of hydrogen peroxides and protects the tissues against reactive hydroxyl radicals [21].

According to our results, chamomile tea consumption caused a considerable increase in TAC level, SOD, GSH-Px, and CAT activity and decreased MDA levels. Such valuable results might be due to chamomile's antihyperglycemic property, which was demonstrated in the treated group.

Our findings also were comparable with findings of other studies which reported decreased serum MDA and increased CAT and GSH-Px activity [22], elevated TAC levels [40], reduced serum MDA levels, and increased CAT and SOD activity [21] in diabetic rats after administrations of chamomile aqueous or ethanolic extracts. Moreover several studies demonstrated that aqueous extracts of chamomile had higher activity than the ethanolic ones [15]. Other studies showed moderate antioxidant activity of chamomile methanolic, ethanolic, or aqueous extracts in comparison with a selection of other medicinal plants [18,41–43]. Braga et al. reported that α-Bisabolol, one of the active components of chamomile [20], improved the antioxidant network and restored the redox balance by antagonizing oxidative stress [44]. In the study by Yoo et al., chamomile enhanced the activity of antioxidative enzymes such as SOD and CAT and cell viability in a dose-dependent manner. In the same study, chamomile provided protective effects against oxidative stress induced by hydrogen peroxide in lung fibroblasts [45].

It was demonstrated that chamomile has high levels of polyphenolic compounds such as coumarins and flavonoids which are reported to produce free radical scavenger actions. The coumarins, herniarin, umbelliferone, and esculetin make up approximately 0.1% of the total constituents. The major flavonoids components are apigenin, luteolin, and quercetin, which comprise 16.8, 1.9, and 9.9% of total flavonoids [24]. Hence, chamomile is one of the richest sources of dietary antioxidants. Our results confirmed that chamomile tea had antioxidant capability and ameliorated the oxidative stress in studied subjects. It was possible that the increase in TAC and activities of enzymatic antioxidants in our chamomile treated group might be due to their decreased consumption for free radical detoxification or utilization which was approved by following decrease in serum MDA and enhancement in TAC levels. Therefore, the antihyperglycemic and antioxidant effect of chamomile tea may be ascribed for the reduction of oxidative stress.

Besides the mechanisms mentioned above, Kholoud and Manal reported that another possible protective effect of chamomile against oxidative stress, at least in part, might be via restoration of nitric oxide availability [22]. Nevertheless, we did not evaluate this phenomenon in our subjects. Further studies are warranted to evaluate the availability of nitric oxide in patients with diabetes. Collectively, on the basis of our

findings, the research hypotheses regarding chamomile tea consumption would ameliorate glycemic and antioxidant indices in subjects with T2 DM were accepted.

It should be noted that in the present study, the subjects were asked to maintain their former diet during the study and data indicated that the subject's diet did not change significantly during the intervention trial. Thus, dietary factors could not be considered as confounding factors in the interpretation of studied biochemical variables. It was also expected that the randomized design could balance eventual bias between the study and control groups. However, our study had some limitations, including its single blind design, short study duration of 8 wk, and discrepancy regarding sex. In addition, effects of chamomile components on metabolic parameters may be dose dependent [21]. The interpretation of the results of our present study may not be applicable for using other amounts of chamomile tea or other intervention periods or for patients under other diabetic medications.

Conclusion

The present study demonstrates that short term intake of chamomile tea had beneficial effects on glycemic control and antioxidant status in patients with T2 DM. A larger sample population and a longer intervention period may be required to show significant clinical improvements.

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