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Effect of maternal dietary consumption pattern of thyme and sesame on fasting blood glucose among women with gestational diabetes

Mai A Gharib [1], Hala M Ayoub [2], Tunny S Purayidathil [2], Norah H Al-Qahtani [3], Reham S Metwally [2]

Authors Affiliation
[1] Department of Nutrition and Food Sciences, Faculty of Home Economics, Menoufia University, Shibin El-Kom, Egypt.
[2] Department of Clinical Nutrition, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Saudi Arabia.
[3] King Fahad University Hospital, Imam Abdulrahman Bin Faisal University, Al-Khobar, Saudi Arabia.

Correspondence to: Metwally RS
rsmetwally@iau.edu.sa

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Abstract

Gestational diabetes mellitus (GDM) is a frequent pregnancy disease. Thyme and sesame were reported to have antihyperglycemic and anti-inflammatory effects. Therefore, they have the potential to be an alternative and safe option for ameliorating GDM. The primary objective of this study was to investigate the relationship of the dietary consumption of thyme and sesame and glucose homeostasis among pregnant women with GDM and non-diabetic pregnant women. A cross-sectional, retrospective study was performed on a sample of 129 pregnant women from Eastern Province in Saudi Arabia. Nutritional assessment of pregnant women included socioeconomic, anthropometric, dietary, and biochemical variables. The biochemical analysis included oral glucose tolerance, fasting glucose, and random glucose levels. The results showed that there is an inverse association between dietary intake of thyme or sesame seeds and fasting blood glucose levels ($P<0.001$) in both pregnant women with GDM and non-diabetic pregnant women. With an increase in the amount of both thyme and sesame consumed, blood glucose levels significantly decreased ($P<0.001$). Moreover, the results showed that the higher the consumption of both thyme and sesame seeds, the lower the weight gain during pregnancy ($P<0.001$ and $P<0.05$, respectively). This association was observed only in pregnant women with GDM. In Conclusion, the findings of this research suggested that dietary consumption of thyme and sesame seeds can be used as hypoglycemic agents for women with GDM.

Keywords: Diet, Nutrition, Pregnant, Women, Cross-sectional, Medicinal Plants

1. Introduction:

GESTATIONAL diabetes mellitus (GDM) is a frequent pregnancy-related illness [1]. Increased blood sugar in pregnant women is one of the pregnancy complications detected for the first-time during pregnancy [2]. Several risk factors contribute to this illness, and extensive attempts have been conducted in recent decades to identify other risk factors to avoid gestational diabetes [3]. The frequency of GDM among Saudi women is high, and the significant risk variables for gestational diabetes were older maternal age, higher BMI, hypertension, a history of gestational diabetes in previous pregnancies, a history of having a malformed child, and a diabetes family history [4].

Recent studies has focused on maternal eating behaviors during adolescence [5] and pregnancy as a risk factors [6]. Utilizing a traditional diet and medications produced from natural sources is the cornerstone of gestational diabetes management [7]. Among them, thyme, which belongs to the family Lamiaceae, is used frequently as a culinary herb. Additionally, it has a long history of use for many culinary and medical applications [8]. The aqueous extract of the thymus contains specific agents responsible for its hypoglycemic activity [9]. The presence of alkaloids, indole alkaloids, flavonoids, tannins, terpenoids, reducing sugars, steroids, and cardiac glycosides were confirmed by phytochemical analysis of the aqueous extract. Also, According to a recent study by Soleimani et al. [10] the thymus species may have anti-inflammation, antioxidant, and hypoglycemic properties. Moreover, thymus could help manage diabetes and hypercholesterolemia [11].

Sesame (Sesamum indicum L.) seeds contain sesamin, sesamolin, and sesaminol glucosides are among the furfural lignans with favorable physiological properties [12]. The addition of flax and sesame seeds to the diet of diabetic pregnant rats helps to reduce diabetic problems in adult mothers and their offspring [13]. Furthermore, Sankar et al. [14] discovered that sesame oil had a synergistic impact with glibenclamide, suggesting it could be a safe and effective medication combination for treating hyperglycemia in clinical practice.

Therefore, this study had designed to explore the correlation between the intake of thyme and sesame and glucose homeostasis in women diagnosed with GDM during early pregnancy in the eastern province of Saudi Arabia.

2. Subjects and Methods

2.1 Subjects

This cross-sectional, retrospective study was carried out on pregnant women aged 20 to 45 years (n = 129). Gestational diabetic women (GDM) (n=100) and control subjects which is non-diabetic pregnant women (CG) (n=29] had recruited after being diagnosed by a consultant in the King Fahad University Hospital's Obstetrics and Gynecology Clinic, Imam Abdulrahman Bin Faisal University, Al-Qatif Central Hospital, Al-Mowasat Hospital, Al-Manaa Hospital, Maternal and Childbirth Hospital, and Medical Family Clinic in the Eastern Province of Saudi Arabia.

Residents of Saudi Arabia's Eastern Province and pregnant women in their second or third trimester of pregnancy were included in the study. The inclusion criteria for the non-diabetic group were 20 to 45-year-old pregnant women without GDM. The GDM group, on the other hand, had gestational diabetes mellitus (fasting glucose more than 126 mg/dL) as defined by the Diagnosis and Classification of Diabetes Mellitus [15].

Women with diabetes or a problem affecting glucose metabolism, infection, or chronic illness are excluded (any gastrointestinal tract malabsorption and thyroid and parathyroid diseases), smoking, and taking any medications for chronic diseases.

2.2 Methods

2.2.1 Assessment of dietary and biochemical variables:

Both non-diabetic and diabetic groups (CG and GDM) were questioned about specific data, including socioeconomic status, anthropometrics (body weight and height), body mass index (BMI, which is based on pre-pregnancy weight), health history, and food habits. Following the principles given by Pritchard et al. [16], a semi-quantitative food frequency questionnaire (FFQ) was developed to assess the consumption of thyme and sesame and their portion sizes (5-10 and >10- 15 grams) based on their average consumption. In addition, the researchers inquired about diets over the previous week or month.

The hexokinase technique (Glucoquant, Roche Diagnostics, Mannheim, Germany) was used to determine biochemical measures for oral glucose tolerance (OGT), fasting glucose (FG), and random glucose levels (RG), as recommended by the American Diabetes Association [15].

2.2.2 Ethical consideration:

The study protocol was explained to all participants, and signed consent was collected before enrolling in the study. The project application and protocol were reviewed and approved by the Institutional Review Board (IRB) Committee of Imam Abdulrahman Bin Faisal University and have the approval number (IRB-UGS-2017-03-033).

2.2.3 Statistical analysis

The gathered data were statistically analyzed to determine the categorical variables' frequency distribution and means and standard deviations (±SD) for continuous variables. Independent sample t-test and Chi-square test were used to verify differences between the study groups using the Statistical Package of Social Science (SPSS ver. 23). The level of significance was set at P less than 0.05.

3. Results

The results revealed that, except for body height, pregnant women with GDM (GDG) have significantly lower anthropometrics compared to non-diabetic pregnant women (CG) (Table 1). The mean±SD age of the CG was 32.5±5.2, while it was 30.6±5.4 years old for the GDG. There was a significant difference between GDG and CG in terms of pre-pregnancy weight (58.6±7.6 vs. 66.6±9.9 kg respectively at $P< 0.05$) and weight gain during pregnancy (12.7±2.1 vs. 17.9±2.9 kg respectively at $P<0.001$). Concerning BMI, CG was graded in the overweight class (BMI = 26.0±4.4 kg/m^2), whereas the GDG was graded in the normal weight class (BMI=23.8±3.2 kg/m^2 at $P < 0.05$).

With regard to serum glucose tests, a significant difference was observed between the GDG and CG (Table 2). The GDG showed significantly higher fasting blood glucose (FG), random glucose (RG), and oral glucose tolerance (OGT) values compared to the CG ($P<0.001$, $P<0.05$, and $P<0.05$, respectively).The dietary intake pattern of thyme differed significantly between the CG and the GDG (Table 3). Thyme was observed to be consumed more frequently among the CG compared to the GDG, as the percentage of the women consuming more than 15 gm/ day of thyme was higher in the CG (58.6%) compared to the GDG group (17%) (15 gm/day consumption was the highest consumption in this study). Furthermore, the dietary consumption of sesame didn't differ between the CG and the GDG.

Table 1. Anthropometric measurements of pregnant women with gestational diabetes and non-diabetic pregnant women.

Variables	CG (n=29) Mean±SD	GDG (n=100) Mean±SD	P-value
Age (years)	32.5±5.2	30.6±5.4	0.061
Height (cm)	160.4±8.6	156.9±4.7	0.043*
Pre-pregnancy weight (kg)	66.6±9.9	58.6±7.6	0.037*
BMI (kg/m^2)	26.0±4.4	23.8±3.2	0.013*
Actual weight (kg)	83.2±10.1	76.5±7.0	0.001***
Weight Gain (kg)	17.9±2.9	12.7±2.1	0.001***

*CG= non-diabetic group; GDG= gestational diabetes group; %: percentage; SD: standard deviation. * Significant at P<0.05, and *** P<0.001.*

Table 2. Blood glucose indices among pregnant women with gestational diabetes and non-diabetic pregnant women.

Blood glucose tests	CG (n=29) Mean ± SD	GDG (n=100) Mean ± SD	P-value
FG (mg/dL)	89.4±8.2	118.8±19.1	0.001***
RG (mg/dL)	131.0±21.2	286.0±67.9	0.027*
OGT (mg/dL)	119.1±.256	154.7±.359	0.022*

*CG: non-diabetic group; GDG: gestational diabetes group; OGT: Oral Glucose Tolerance; FG: Fasting Glucose; RG: Random Glucose. * Significant at P<0.05, and *** P<0.001.*

Table 3. Dietary consumption pattern of Thyme and sesame among pregnant women with gestational diabetes and non-diabetic pregnant women.

	Thyme					Sesame				
	CG (N=29)		GDG (N=100)		P-value	CG (N=29)		GDG (N=100)		P-value
	No	%	No	%		No	%	No	%	
Not taken	0	0	2	2		2	6.9	12	12	
5-10 g /mo	1	3.4	5	5		2	6.9	9	9	
>10- 15 g /mo	1	3.4	6	6		1	3.4	15	15	
5-10 g /wk	2	6.9	14	14	0.002**	6	20.7	17	17	0.338^{NS}
>10- 15 g /wk	3	10.3	10	10		9	31	23	23	
5-10 g /day	5	17.2	46	46		3	10.3	15	15	
>10- 15 g /day	17	58.6	17	17		6	20.7	9	9	

CG: non-diabetic group; GDG: gestational diabetes group; SD: standard deviation. NS: not significant

The dietary consumption of both the thyme and sesame seeds was inversely associated with the levels of fasting blood glucose in both GDG and CG (P<0.001) (Tables 4 and 5). Moreover, an increase in thyme and sesame intake was associated with a progressive reduction in serum glucose concentrations. In the GDG, the lowest blood glucose level (91.2± 9.2 mg/dL) was reported with the highest thyme intake (15 gm/day), whereas the non-thyme consumer group showed the highest blood glucose level (134.0±1.4 mg/dL). Similarly, the most significant decline in the blood glucose level (83.4±2.7 mg/dL) was observed with the highest sesame intake (15 gm/ day).

The BMI (estimation based on pre-pregnancy weight). The CG was classified as normal weight, ranging from 19.4±5.3 kg/m2 with 5g per month to 25.8±3.5 kg/m2 with 5g per week consumptions, but did not reveal a significant correlation. However, a significant association between thyme consumption pattern and body mass index was found in GDG at P<0.05 (Table 6). In contrast, the results did not indicate a significant relationship between sesame consumption and BMI in either CG or GDG (Table 7).

Table 4. Relationship between fasting glucose profile and the dietary consumption of Thyme among pregnant women with gestational diabetes and non-diabetic pregnant women.

Thyme	Fasting blood glucose (mg/dL)			
	CG (N= 29)	P-value	GDG (N=100)	P-value
Not taken	--		134.0±1.4	
5-10 g /mo	120.0±1.0		120.8±15.6	
>10- 15 g /mo	125.0±4.4		119.2±4.6	
5-10 g /wk	114.5±7.8	<0.001	112.6±7.2	0.001***
>10- 15 g /wk	91.7±6.0		100.9±1.6	
5-10 g /day	101.8±9.1		97.4±9.4	
>10- 15 g /day	97.4±11.5		91.2±9.2	

*CG: non-diabetic group; GDG: gestational diabetic group; the values are means ± SD. *** Significant at P<0.001.*

Table 5. Relationship between fasting glucose profile and the dietary consumption of sesame among pregnant women with gestational diabetes and non-diabetic pregnant women.

Sesame	Fasting blood glucose (gm/dL)			
	CG (N= 29)	p value	GDG (N= 100)	P-value
Not taken	122.5±3.5		116.8±10.6	
5-10 g /mo	117.5± 3.4		110.0±11.9	
>10- 15 g /mo	99.0 ±1.0		113.6±10.9	
5-10 g /wk	100.0±7.9	<0.001	97.1±2.4	0.001***
>10- 15 g /wk	96.7±3.9		103.9± 6.7	
5-10 g /day	88.3 ± 1.5		88.2±5.5	
>10- 15 g /day	85.3±2.3		83.4±2.7	

*CG: non-diabetic group; GDG: gestational diabetic group; the values are means ± SD. *** Significant at P<0.001*

Table 6. Relationship between the Thyme consumption pattern and the BMI of pregnant women with gestational diabetes and non-diabetic pregnant women

Thyme	BMI (Kg/ m^2)			
	CG (N= 29)	P-value	GDG (N= 100)	P-value
Not taken	--		22.2±5.4	
5-10 g /mo	19.4±5.3		24.6±3.3	
>10- 15 g /mo	24.0±6.2		28.7±3.0	
5-10 g /wk	25.8±3.5	0.628NS	25.6±3.4	0.013*
>10- 15 g /wk	24.0±2.8		27.1±5.4	
5-10 g /day	25.1±4.2		25.8±4.7	
>10- 15 g /day	23.4±3.1		26.2±4.1	

*CG: non-diabetic group; GDG: gestational diabetes group; SD: standard deviation; * *** Significant at P<0.05.*

The BMI was estimated based on pre-pregnancy weight. The CG was classified as normal weight, ranging from 19.4±5.3 kg/m2 with 5g per month consumption to

25.8±3.5 kg/m2 with 5g per week consumption, but did not reveal a significant correlation. However, a significant association between thyme consumption pattern and body mass index was found in GDG at (P≤ 0.05) (Table 6). In contrast, the results did not indicate a significant relationship between sesame consumption and BMI in either CG or GDG (Table 7).

Regarding weight gain during pregnancy, results showed that the higher the consumption of both sesame seeds and thyme, the lower the weight gained during pregnancy in the GDG (Tables 8 and 9). No significant association between weight gain and intake of sesame or thyme was observed in the CG (Tables 8 and 9).

Table7. Relationship between the sesame consumption pattern and the BMI of pregnant women with gestational diabetes and non-diabetic pregnant women.

Sesame	BMI (Kg/ m^2)			
	CG (N= 29)	P-value	GDG (N= 100)	P-value
Not taken	23.7±0.5		25.2±4.0	
5-10 g /mo	24.5±7.2		27.1±4.1	
>10- 15 g /mo	20.8±4.3		26.4±3.6	
5-10 g /wk	25.1±3.7	0.318NS	26.3±6.0	0.743NS
>10- 15 g /wk	22.3±2.5		26.0±4.5	
5-10 g /day	27.1±2.1		26.7±3.9	
>10- 15 g /day	23.5±3.1		24.0±3.1	

*CG: non-diabetic group; GDG: gestational diabetes group; SD: standard deviation; * Significant at P<0.05.*

Table 8. Relationship between Thyme consumption pattern and the weight gain during pregnancy among pregnant women with gestational diabetes and non-diabetic pregnant women.

Thyme	Weight gain (kg)			
	CG (N= 29)	P-value	GDG (N= 100)	P-value
Not taken	0		24.0±5.7	
5-10 g /mo	19.0±2.3		18.0±2.3	
>10- 15 g /mo	20.0±3.5		17.3±0.9	
5-10 g /wk	18.2±1.7	0.366NS	20.1±3.5	0.037*
>10- 15 g /wk	19.0±0.5		16.0±1.0	
5-10 g /day	18.9±1.9		15.9±1.8	
>10- 15 g /day	17.1±2.2		15.0±2.4	

*CG: non-diabetic group; GDG: gestational diabetes group; SD: standard deviation; * Significant at P<0.05.*

4. Discussion:

The use of medicinal plants and their derivatives remains a significant treatment option for treating many disorders. Despite the development of new medicines, undesirable effects continue to pose a significant threat to the treatment of diabetes. For such cause, there is a growing demand for oral hypoglycemic treatments with fewer side effects than those now employed in the medical care system. Natural anti-hyperglycemic medications were shown to have fewer adverse effects than synthetic oral hypoglycemic medications.

According to recent studies, roughly 30% of diabetic patients use complementary and alternative therapy [17]. Furthermore, thyme reduced hyperglycemia levels in STZ/NA-induced mice in a way comparable to regular metformin [17]. Thymus is a plant genus in the Lamiaceae family, is a culinary herb that is widely used. It has also been used for a long time for various dietary and medical reasons [18]. Thymus genus has been used for its beneficial health-promoting properties since ancient times, which could be attributed to its active compounds, particularly essential oils (EOs) [19], which are distinguished by its inclusion of isomeric phenolic monoterpenes in high quantity (e.g. thymol, carvacrol, linalool, -terpineol, geraniol, borneol, and thujanol) [20,21].

Table 9. Relationship between sesame consumption pattern and the weight gain during pregnancy among pregnant women with gestational diabetes and non-diabetic pregnant women

	Weight gain (kg)			
Sesame	CG (N= 29)	P-value	GDG (N= 100)	P-value
Not taken	18.5±2.1		21.6±3.7	
5-10 g /mo	19.5±0.7		18.2±2.2	
>10- 15 g /mo	18.0±4.2		17.5±0.9	
5-10 g /wk	17.9±2.1	0.412NS	16.0±1.2	<0.001***
>10- 15 g /wk	18.7±2.4		15.6±1.5	
5-10 g /day	17.5±1.3		14.8±1.6	
>10- 15 g /day	16.4±2.0		14.2±2.3	

*CG: non-diabetic group; GDG: gestational diabetes group; SD: standard deviation; *** Significant at P<0.001.*

Previous studies also demonstrated that aqueous extract of the thymus contains specific hypoglycemic agents responsible for its hypoglycemic activity [9]. The phytochemical examination proved the presence of alkaloids, indole alkaloids, flavonoids, tannins, terpenoids, reducing sugars, steroids, and cardiac glycosides in the aqueous extract. The alkaloids and terpenoids have also been reported to possess significant antidiabetic potential [22]. The flavonoids are known to possess an antidiabetic activity and have been studied to regenerate the damaged β-cells in alloxan-diabetic rats [23]. Glycosides, alkaloids, and terpenoids are frequently implicated as having an antidiabetic effect [24]. Also, a recent study by Soleimani et al. [10] demonstrated that thymus has anti-inflammatory, antioxidant, and anti-diabetic properties.

Taleb et al. [25] carried out a clinical trial to determine the effects of T. kotschyanus aqueous extract on hypoglycemic and hypolipidemic parameters among patients with type 2 DM. The results demonstrated a substantial improvement in beta-cell function index and a significant reduction in serum glucose, HbA1C, and LDLc concentrations in the group treated with both thymus extract and the antidiabetic drug, indicating better glucose management. Salehi et al. [11] indicated that the thymus might aid in the management of diabetes and hypercholesterolemia.

According to the literature, diabetes individuals often report an increase in intestinal alpha-glucosidase after meals. As a result, alpha-glucosidase inhibitors help people with diabetes and obesity [26]; in the study of Cam et al. [18], they found that thymus praecox subsp extract reduced serum glucose concentrations by inhibiting activity of alpha-glucosidase and suppressing the increase of blood glucose levels OGTT. Thymus serpyllum possesses anti-diabetic potential due to its alpha-glucosidase inhibitory properties.

As noted in the study of Cam et al. [18], thyme's anti-diabetic properties Help restore glycemic control, minimize pancreatic cell damage, and increase insulin sensitivity. These effects might be attributable to SGLT-1, SGLT-2, GLUT2, PEPCK, alpha-glucosidase inhibition, and GLP-1 activation in STZ/NA-induced diabetic mice. According to these studies, TPSE may be effective in treating diabetes, and the benefits may be due to chlorogenic acid components, luteolin-7-O-glucoside, 3-O-feruloyl quinic acid, quercetin-3-O-hexoside, and apigenin-7-O-glucuronide.

Moreover, the thymus genus demonstrated antioxidant activity in a previous study [27]. So, the active principles might protect the β-cells of the islets of Langerhans from oxidative stress and might contribute to the hypoglycemic activity of the aqueous extract. In line with these findings, thyme might be advised to manage diabetes, as Alamgeer et al. [28] concluded.

A sesame seed, which contains ample levels of furfural lignans with favorable physiological effects, primarily sesamin, sesamolin, and sesaminol glucosides, was also employed in this investigation [12]. Nowadays, sesame seed lignans are available as Nutraceuticals and sold as capsules for antioxidant activity and life enhancement, according to previous research [29].

In the present study, we observed a highly significant association between fasting glucose profile and frequent dietary consumption of sesame among both the non-diabetic and the gestational diabetic women. Other studies supported these observations that demonstrated that in mice and T2DM women, defatted sesame seeds were found to have hypoglycemic effects [30]. Furthermore, a similar study found that adding flax and sesame seeds to the diet of diabetic pregnant rats might help reduce diabetes problems in adult mothers and their offspring [13]. Furthermore, Sankar et al. [14] discovered that sesame oil had a synergistic impact with glibenclamide, suggesting that it might be a safe and effective medication combination for treating consumption of sesame helps lower blood glucose levels among gestational diabetic women compared to the non-diabetic group. The results of the current study support previous research showing that SES has hypoglycemic effects in type 2 diabetic animal models by reducing insulin resistance [31,32]. In addition, some investigations have revealed that SES therapy protects pancreatic cells against STZ-induced damage via antioxidant and anti-inflammatory pathways [33,34].

Regarding body weight gain during pregnancy, the results of this study showed a significant inverse association between the consumption of both sesame seeds and thyme and the weight gained during pregnancy among gestational diabetic women compared to non-diabetic pregnant women. These results were in accordance with those previously reported by Papiya et al . [35], who concluded that supplementing with sesame seed cakes might be used as a treatment technique to reduce Type 2 hyperglycemia caused by obesity. In addition, Hong et al. [31] demonstrated that sesamin exhibits hypoglycemic, hypolipidemic, and insulin-resistance-relieving properties in KK-Ay mice, which might be due to its action on insulin receptors, which promotes insulin sensitivity.

In the current study, the results revealed that sesame seed consumption ameliorates the glucose level and the body weight. These findings were similar to those reported by Thuy et al. [36], who found that giving rats with type 1 diabetes sesamin for four weeks improved serum glucose concentrations, and body weight and dramatically reduced the effects on heart rate and blood pressure when compared to control rats.

5. Conclusion:

In conclusion, this study suggests that dietary consumption of thymus and sesame seeds, these two commonly used and available plants, is one way to improve glucose homeostasis in women with GDM. However, further human intervention studies are needed to validate their impact on glycemic control and the underlying mechanisms of their effect.

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Conflict of interest

This research holds no conflict of interest.

Author contribution

All authors have contributed to collecting and analyzing data and writing the manuscript. Metwally RS was responsible for revising and editing the manuscript.

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References:

[1] Alamolhoda SH, Simbar M, Mirmiran P, Mirabi P. The effectiveness of low trans-fatty acids dietary pattern in pregnancy and the risk of gestational diabetes mellitus. Caspian J Intern Med. 2019 Spring;10(2):197-204. doi:10.22088/cjim.10.2.197. [PubMed] [Google Scholar].

[2] American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2013 Jan;36 Suppl 1(Suppl 1):S67-74. doi:10.2337/dc13-S067 [PubMed] [Google Scholar].

[3] Hartling L, Dryden DM, Guthrie A, Muise M, Vandermeer B, Aktary WM, et al. Screening and diagnosing gestational diabetes mellitus. *Evid Rep Technol Assess* (Full Rep). 2012 Oct;[210):1-327. [PubMed] [Google Scholar].

[4] Alfadhli EM, Osman EN, Basri TH, Mansuri NS, Youssef MH, Assaaedi SA, et al. Gestational diabetes among Saudi women: prevalence, risk factors and pregnancy outcomes. *Ann Saudi Med*. 2015 May-Jun;35(3):222-30. doi:10.5144/0256-4947.2015.222. [PubMed] [Google Scholar].

[5] Abuzaid OI, Alkhalaf SA, Alessa HA, Al-Ghamdi SA, Bawazier SS, Badr Eldin MS. Relationship between Food Habits and Body Weight of Saudi Adolescent Females, Cross-Sectional Study. *Journal of Applied Nutritional Sciences*. 2022; 1(1): 26-37. doi:10.18576/jans/010103. [Google Scholar].

[6] Zhang C, Ning Y. Effect of dietary and lifestyle factors on the risk of gestational diabetes: review of epidemiologic evidence. *Am J Clin Nutr*. 2011 Dec;94 (6 Suppl): 1975S-1979S. doi:10.3945/ajcn.110.001032 [PubMed] [Google Scholar].

[7] Ismail EM, Ismail MS. Dietary Awareness of Saudi Women with Gestational Diabetes. Food and Public Health. 2013;3(6):341-5. doi:10.5923/j.fph.20130306.12. [Google Scholar].

[8] Salehi B, Mishra AP, Shukla I, Sharifi-Rad M, Contreras MDM, Segura-Carretero A, et al. Thymol, Thyme, and other plant sources: Health and potential uses. *Phytother Res*. 2018 Sep;32(9):1688-1706. doi: 10.1002/ptr.6109. [PubMed] [Google Scholar].

[9] Ahmad M, Alamgeer, Sharif T. A potential adjunct to insulin: Berberis lycium Royle. *Diabetologia Croatica*. 2009, 38(1): 13-18. [Google Scholar].

[10] Soleimani Farsani M, Behbahani M, Isfahani HZ. The Effect of Root Shoot and Seed Extracts of The Iranian Thymus L. (Family: *Lamiaceae*) Species on HIV-1 replication and CD4 Expression. *Cell J.* 2016 Jul-Sep;18(2):255-61. doi: 10.22074/cellj.2016.4321. [PubMed] [Google Scholar].

[11] Salehi B, Abu-Darwish MS, Tarawneh A, Cabral C, Gadetskaya AV, Salgueiro L, et al. Thymus spp. plants - Food applications and phytopharmacy properties. *Trends in Food Science & Technology*. 2019, 287-306. DOI:10.1016/J.TIFS.2019.01.020 [Google Scholar].

[12] Kamal-Eldin A, Moazzami A, Washi S. Sesame seed lignans: potent physiological modulators and possible ingredients in functional foods & nutraceuticals. *Recent Pat Food Nutr Agric*. 2011 Jan;3(1):17-29. doi: 10.2174/2212798411103010017. [PubMed] [Google Scholar].

[13] Makni M, Sefi M, Garoui el M, Fetoui H, Boudawara T, Zeghal N. Dietary polyunsaturated fatty acid prevents hyperlipidemia and hepatic oxidant status in pregnant diabetic rats and their macrosomic offspring. *J Diabetes Complications*. 2011 Jul-Aug;25(4):267-74. doi: 10.1016/j.jdiacomp.2011.02.002 [PubMed] [Google Scholar].

[14] Sankar D, Ali A, Sambandam G, Rao R. Sesame oil exhibits synergistic effect with anti-diabetic medication in patients with type 2 diabetes mellitus. *Clin Nutr*. 2011 Jun;30(3):351-8. doi: 10.1016/j.clnu.2010.11.005. [PubMed] [Google Scholar].

[15] American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2019. *Diabetes Care*. 2019. Jan;42(Suppl 1):S13-S28. doi: 10.2337/dc19-S002. [PubMed] [Google Scholar].

[16] Pritchard JM, Seechurn T, Atkinson SA. A food frequency questionnaire for the assessment of calcium, vitamin D and vitamin K: a pilot validation study. *Nutrients*. 2010 Aug;2(8):805-19. doi: 10.3390/nu2080805. Epub 2010 Jul 28. [PubMed] [Google Scholar].

[17] Shewamene Z, Abdelwuhab M, Birhanu Z. Methanolic leaf exctract of Otostegia integrifolia Benth reduces blood glucose levels in diabetic, glucose loaded and normal rodents. *BMC Complement Altern Med*. 2015 Feb 7;15:19. doi: 10.1186/s12906-015-0535-5. [PubMed] [Google Scholar].

[18] Cam ME, Yildiz S, Ertaş B, Acar A, Taşkın T, Kabasakal L. Antidiabetic effects of Salvia triloba and Thymus praecox subsp. skorpilii var. skorpilii in a rat model of streptozotocin/nicotinamide-induced diabetes. *Marmara Pharmaceutical Journal*, 2017; 21, 818-827. DOI:10.12991/MPJ.2017.8. [Google Scholar].

[19] Casiglia S, Bruno M, Scandolera E, Senatore F, Senatore F. Influence of harvesting time on composition of the essential oil of Thymus capitatus (L.) Hoffmanns. & Link. growing wild in northern Sicily and its activity on microorganisms affecting historical art crafts. *Arabian Journal of Chemistry, 2015, 12*, 2704-2712. doi:10.1016/J.ARABJC.2015.05.017 [Google Scholar].

[20] Imen Ben El Hadj A, Arbi G, Mohamed B. Chemical and genetic variability of Thymus algeriensis Boiss. et Reut. (Lamiaceae), a North African endemic species. *Industrial Crops and Products*. 2012;40:277-84 [Google Scholar].

[21] Tohidi B, Rahimmalek M, Arzani A. Essential oil composition, total phenolic, flavonoid contents, and antioxidant activity of Thymus species collected from different regions of Iran. *Food Chem*. 2017 Apr 1;220:153-161.doi:10.1016/j.foodchem.2016.09.203 [PubMed] [Google Scholar].

[22] Loew D, Kaszkin M. Approaching the problem of bioequivalence of herbal medicinal products. *Phytother Res*. 2002 Dec;16 (8):705-11. doi:10.1002/ptr.1248 [PubMed] [Google Scholar].

[23] Charkravarthy BK, Gupta S, Gambir SS and Gode KD. Pancreatic beta cell regeneration. A novel antidiabetic mechanism of Pterocarpus marsupium Roxb. *Ind. J. Pharmacol*. 1980, 12: 123-127 [Google Scholar].

[24] Malviya N, Jain S, Malviya S. Antidiabetic potential of medicinal plants. *Acta Pol Pharm*. 2010 Mar-Apr;67(2):113-8 [PubMed] [Google Scholar].

[25] Taleb A, Qannadi F, Changizi-Ashtiyani S, Zarei A, Rezvanfar M, Akbari A et al . The Effect of Aqueous Extract Thymus kotschyanus Boiss. et Hohen on Glycemic Control and Dyslipidemia Associated with Type II Diabetes: a Randomized Controlled Trial. *Iranian Journal of Endocrinology and Metabolism*. 2017; 19 (4) :234-243. URL: http://ijem.sbmu.ac.ir/article-1-2225-en.html [Google Scholar].

[26] Watanabe J, Kawabata J, Kurihara H, Niki R. Isolation and identification of alpha-glucosidase inhibitors from Tochu-cha (*Eucommia ulmoides*). *Biosci Biotechnol Biochem*. 1997 Jan;61(1):177-8. doi: 10.1271/bbb.61.177 [PubMed] [Google Scholar].

[27] Pandey MC, Sharma JR, Dikshit A. Antifungal evaluation of the essential oil of Cymbopogon pendulus (Nees ex Steud.) Wats. cv. Praman. *Flavour and Fragrance Journal*. 1996 Jul;11(4):257-60 [Google Scholar].

[28] Alamgeer -, Mushtaq MN, Bashir S, Ullah I, Karim S, Rashid M, Malik MN, Rashid H. Comparative hypoglycemic activity of different fractions of Thymus serpyllum L. in alloxan induced diabetic rabbits. *Pak J Pharm Sci*. 2016 Sep;29(5):1483-1488 [PubMed] [Google Scholar].

[29] Ide T, Lim JS, Odbayar TO, Nakashima Y. Comparative study of sesame lignans (sesamin, episesamin and sesamolin) affecting gene expression profile and fatty acid oxidation in rat liver. *J Nutr Sci Vitaminol (Tokyo)*. 2009 Feb;55(1):31-43. doi: 10.3177/jnsv.55.31 [PubMed] [Google Scholar].

[30] Wikul A, Damsud T, Kataoka K, Phuwapraisirisan P. (+)-Pinoresinol is a putative hypoglycemic agent in defatted sesame (Sesamum indicum) seeds though inhibiting α-glucosidase. *Bioorg Med Chem Lett*. 2012 Aug 15;22(16):5215-7. doi: 10.1016/j.bmcl.2012.06.068 [PubMed] [Google Scholar]

[31] Hong L, Yi W, Liangliang C, Juncheng H, Qin W, Xiaoxiang Z. Hypoglycaemic and hypolipidemic activities of sesamin from sesame meal and its ability to ameliorate insulin resistance in KK-Ay mice. *J Sci Food Agric*. 2013 Jun;93(8):1833-8. doi: 10.1002/jsfa.5974 [PubMed] [Google Scholar].

[32] Song MK, Roufogalis BD, Huang TH. Modulation of diabetic retinopathy pathophysiology by natural medicines through PPAR-γ-related pharmacology. *Br J Pharmacol*. 2012 Jan;165(1):4-19. doi: 10.1111/j.1476-5381.2011.01411.x [PubMed] [Google Scholar].

[33] Shen JH, Ma Q, Shen SR, Xu GT, Das UN. Effect of α-linolenic acid on streptozotocin-induced diabetic retinopathy indices in vivo. *Arch Med Res*. 2013 Oct; 44 (7): 514-20. doi: 10.1016/j.arcmed.2013.09.010[PubMed] [Google Scholar].

34] Ahmad S, ElSherbiny NM, Jamal MS, Alzahrani FA, Haque R, Khan R, Zaidi SK, et al. Anti-inflammatory role of sesamin in STZ induced mice model of diabetic retinopathy. *J Neuroimmunol*. 2016 Jun 15;295-296:47-53. doi:10.1016/j.jneuroim.2016.04.002 [PubMed] [Google Scholar].

[35] Papiya Bigoniya, Ravi Nishad, Chandra Shekhar Singh. Preventive effect of sesame seed cake on hyperglycemia and obesity against high fructose-diet induced Type 2 diabetes in rats. *Food Chemistry*. 2012; 133 (4): 1355-1361. doi.org/10.1016/j.foodchem.2012.01.112 [Google Scholar].

[36] Thuy TD, Phan NN, Wang CY, Yu HG, Wang SY, Huang PL, et al. Novel therapeutic effects of sesamin on diabetes-induced cardiac dysfunction. *Mol Med Rep*. 2017 May;15(5):2949-2956. doi: 10.3892/mmr.2017.6420 [PubMed] [Google Scholar].