Study of Glycemic Control by Ketogenic Diet Supplemented with Different Oils in Type II Diabetic Rats

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ABSTRACT

In recent years, very low carbohydrate ketogenic diets (VLCKD) have been emphasized. While commonly debated and often opposed, these are clearly successful as a method for treating obesity, hyperlipidemia and diabetes at least in the short to medium term. Therefore, this research was conducted to investigate the impact of ketogenic diet (KD) supplemented with oil of either grape seed or fish and virgin olive on diabetic rats. Forty eight male albino rats weighing 200 to 210 g, were assigned into two main groups. The first group (n=8) was control negative group (-ve), the second main group (n=40) were intraperitoneally injected with a single dose of streptozotocin (STZ) [60 mg/kg b.w.] for induction of diabetes, then these rats were divided into five subgroups. Subgroup one was fed on the basal diet and served as a control positive group, while subgroup 2 was fed on KD only and subgroups from 3 to 5 were fed on KD supplemented with 4% oil of either grape seed or fish and virgin olive, respectively for 8 weeks. The results indicated that, STZ treated rats showed significant reduction ($P \leq 0.05$) in serum insulin concentration and increased glucose levels compared to normal rats. KD supplemented with oil of either grape seed or fish and virgin olive improved the biochemical changes due to diabetes. Furthermore, the intervention caused favorable changes in blood lipids and restored liver and kidney functions of the treated rats compared to the control positive group. In conclusion, the ketogenic diet and KD supplemented with oil of either grape seed or fish or virgin olive are potentially promising diets for diabetic patients.

Keywords: Ketogenic diet, diabetes mellitus, grape seed oil, fish oil, virgin olive oil.

INTRODUCTION

In recent decades, the global prevalence of obesity and type 2 diabetes has increased significantly leading to a global epidemic (**NRFC, 2016 and Gregg and Shaw, 2017)**. Globalization, economic development, an increase in sedentary lifestyles, the use of some medications and the dietary transition to high-calorie and processed foods led to this phenomenon **(Piaggi *et al*., 2018)**. High intakes of carbohydrates have recently been associated with a higher risk of total mortality, although lower overall mortality has been correlated with total fat and different forms of fat **(Dehghan *et al*., 2017)**. Consequently, managing obesity and its associated comorbidities has thus become one of the most important issues nowadays.

A ketogenic diet (KD) is a diet rich in fat, sufficient in protein and low in carbohydrates, and known to induce and maintain a kenotic state by generating high levels of ketogenic bodies through fat metabolism **(Boison, 2017)**. Over the past decades, KD has been extended to other neurological or non-neurological diseases and its beneficial effects have been demonstrated **(Koppel and Swerdlow, 2018)**. In particular, KD is one of the most used dietary therapies in recent clinical trials for patients with diabetes or obesity **(Abbasi, 2018)**.

Efficient dietary approaches to avoid and mitigate these changes include the use of such bioactive compounds as vegetable oils , fish oils and the use of polyphenolic compounds as antioxidants for preventive strategies **(Naveen and Baskaran, 2018)**.Grape seed oil (GSO) is a vegetable oil extracted from the grape seeds which consists of up to 7–20 % oil **(Matthaus,2008)**. GSO has recently shown to have several health properties due to its contents of polyphenols, flavonoids and vitamins E and C **(Ranjbar-Zahedani *et al*., 2015)**. GSO also contains high levels of unsaturated fatty acids (UFA) and low levels of saturated fatty acids (SFA), as well as high percentage of linoleic acid. GSO may improve insulin resistance in human **(Irandoost *et al*., 2013)**. It can serve as an important alternative medicinal drug to reduce ß-cell dysfunction **(Lai *et al*., 2014)**. GSO also has been shown to decrease plasma triglycerides and cholesterol **(Javadi *et al.,* 2014)**. Moreover, the GSO phenolic compounds and antioxidants act to reduce the oxidative stress **(Wang *et al*., 2015)**.

Marine omega-3 polyunsaturated fatty acids (PUFAs) have demonstrated protective effects against dietary metabolic changes, including dyslipidemia, insulin resistance **(Taltavull *et al*., 2016)**, and obesity **(Albracht-Schulte *et al*., 2018)**. Fish oil (FO) consumption can decrease the level of free

fatty acids, improve the lipid profile and insulin sensitivity and reduce the incidence of type 2 diabetes **(Albert *et al*., 2014)**.

Virgin Olive oil (VOO) is a functional food with a high content of mono unsaturated fatty acids (MUFA), plus 1% omega-3 PUFA, 73.3% oleic acid (MUFA), 7.9% omega-6 PUFA, and 13.5% saturated fatty acids (SFA) **(Psaltopoulou *et al*., 2011)**. It also includes other minor elements, biologically active, such as polyphenols **(Covas *et al*., 2006)**. The phenolic compounds are essential in stimulating the blood insulin secretion, and this is due to the oleuropein found in olive oil and its role in triggering and releasing insulin and increasing cell glucose intake **(Gonzalez, 2007)**. The phenolic compounds of olive oil have antioxidant properties and also have beneficial effects on various physiological parameters, such as atherosclerosis, obesity, metabolic syndrome, type II diabetes and also has significant influence on lipid metabolism **(Ambra *et al*., 2017)**. So, the aim of the present study was to improve and modify the ketogenic diet by replacing the animal fats by vegetable oils to reduce the bad effects of the traditional ketogenic regimen, Also, the effect of ketogenic diet supplemented with oil of either grape seed or fish or virgin olive on diabetic rats was studied.

Materials and methods

Materials

- Grape seed oil and Virgin olive oil were obtained from Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Fish oil was obtained from Egyptian Indian Company for Natural Products.

- Chemicals: Casein, vitamins, minerals, cellulose, choline chloride and Streptozotocin (STZ) were bought from El- Gomhoria Company, Cairo, Egypt. **Kits** for biochemical analysis were purchased from Biodiagnostic Company for Pharmaceutical and Chemicals, Dokki, Egypt.

- Animals: Forty eight healthy male albino rats (Sprague-Dawley strain) were bought from the Helwan Experimental Animals Station at the age of eight weeks (200 to 210 g.).

Methods:

Induction of animal model of diabetes: Diabetes was induced by a single intraperitoneal injection of freshly prepared STZ (60 mg/kg b.w.) dissolved in 0.1 mol/1 citrate buffer of PH 4.5 **(Al-Hariri, 2012)**. Three days later, the level of the blood glucose was assessed and the level ≥250 mg/dl was considered as diabetic **(Ghauri *et al* .,2020)**.

Experimental Animal Design

Forty eight male albino rats were housed in well aerated cages under hygienic conditions and fed on basal diet for one week for adaptation according to **(Reeves *et al*., 1993)**. After this week rats were divided into two main groups as follows:- The first main group (n=8) was kept as control negative group, the second main group (n=40) was intraperitoneally injected with a single dose of STZ [60 mg/kg b.w.] for induction of diabetes, then these rats were divided into five subgroups (8 rats each). Subgroup one was fed on the basal diet and served as a control positive group, subgroup 2 was fed on ketogenic diet only (standard diet) as shown in table (1) **(Nylen *et al*., 2005)**. Subgroups from 3 to 5 were fed on Ketogenic diet supplemented with 4% oil of (grape seed, fish and virgin olive) respectively.

At the end of the study (8 weeks) the rats were fasted for 12 hours, and then sacrificed under ether anesthesia. Blood samples were obtained from suborbital vein of rats by means of fine capillary glass tubes in a centrifuge tube without any anticoagulant and centrifuged for 20 minutes at 3000 r.p.m. to obtain serum after being left at room temperature for complete clotting.

Table 1. Nutrient composition of basal diet and ketogenic diet

Nutrients	Basal diet (g /kg)	Ketogenic diet	
		(g /kg)	%
Protein (Casein) 20%	200	142.090	16.6
Carbohydrate (starch)	665	4.887	3.4
Fat (Corn oil)	40	737.83	80
Vitamins mixture	10	4.611	
Minerals mixture	35	44.472	
Fiber	50	66.087	
Choline bitartrate	2.5		
L-Cystine	1.8		

Biochemical analysis:

Serum was analyzed for the following biochemical parameters: Insulin activity was estimated using enzyme linked immunosorbent assay ELISA method as described by **Clark and Hales, (1994)**. Glucose level was determined according to **Burrin and Price, (1985)**. Serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured according to **Bergmeyer *et al*. (1978)**. The level of urea and creatinine in serum was estimated spectrophotometrically as described by **Patton and Crouch, (1977**) and **Larsen, (1972),** respectively. Lipid parameters were determined as follows; Triglyceride (TG) according to **Fossati and Prencipe, (1982),** total cholesterol (TC) by the method of **Allian *et al.* (1974)**, high

density lipoprotein- cholesterol (HDL-C) by the method of **Albers *et al.* (1983)**. Calculation of low density lipoprotein-cholesterol (LDL-C) and very low density lipoprotein-cholesterol (VLDL-C) was done according to the equation of **Wallach, (1992)**. Low density lipoprotein-cholesterol can be calculated as follows: LDL-C = Total cholesterol – HDL-C –VLDL-C **Fruchart (1982)**. Where VLDL = triglycerides / 5

Statistical analyses:

The results were expressed as mean ± standard error (SE) and were analyzed statistically using one-way analysis of variance ANOVA. The results were considered significant at $P \leq 0.05$. Calculations were made by SPSS software version 20 (SPSS Inc., Chicago, Illinois, USA) **(Emsley *et al.*, 2010)**.

Results:

Rats injected with STZ had significant ($P \leq 0.05$) higher glucose level but had significant ($P \leq 0.05$) lower insulin concentration, compared to the control negative group Table (2). Feeding diabetic rats on ketogenic diet only or ketogenic diet supplemented with oils of either grape seed or fish or olive caused a significant ($P \leq 0.05$) decrease in the elevated serum glucose level, compared to the control positive group. It was clear that, no significant difference in glucose level among the treated groups with ketogenic diet supplemented with different oils. However, there was a significant difference in serum glucose between the diabetic rats that were fed on ketogenic diet only and the other diabetic rats that fed on ketogenic diet and supplemented with the different oils. The administration with ketogenic diet to diabetic rats caused a significant ($P \leq 0.05$) reduction in glucose level compared to the control positive group.

The percent of glucose reduction as a result of feeding ketogenic diet only or ketogenic diet supplemented with oils (grape seed , fish , virgin olive) are 12.72%, 41.00%, 41.88 and 42.37% respectively, as compared to the value of glucose level in the control positive group. Ketogenic diet supplemented with olive oil caused the highest reduction in glucose level. Regarding to insulin concentration, it was significantly higher in the treated groups with ketogenic diet only or ketogenic diet supplemented with different oils compared to the control diabetic group. Moreover, no significant difference in insulin activity level among the treated groups was noticed. It was obvious that, the treatments with ketogenic diet supplemented with fish oil caused the highest beneficial effect in improving in insulin level.

Table (2): Effect of ketogenic diet on serum glucose and insulin levels of diabetic rats.

Parameters / Groups	Glucose (mg/dl)	%of glucose reduction	Insulin (mIU/ml)
Control (-ve)	81.00±1.76^{d}	-	16.57±0.77^{a}
Control (+ve)	274.40±3.50^{a}	-	7.21±0.62^{c}
Diabetic+ keto diet	178.40±3.70^{b}	34.99	9.25±0.60^{b}
Diabetic+ keto diet (grape seed oil)	120.60±2.06^{c}	56.05	9.37±0.21^{b}
Diabetic+ keto diet (fish oil)	118.80±1.88^{c}	56.71	11.18±0.87^{b}
Diabetic+ keto diet (virgin olive oil)	117.80±7.10^{c}	57.07	10.19±0.65^{b}

Values were expressed as Means ± SE.
Values at the same column with different letters are significant at P≤0.05.

Table (3) illustrates the effect of ketogenic diet supplemented with oils of either grape seed or fish or virgin olive on liver functions of normal and diabetic rats. The activities of serum AST and ALT were significantly increased (P≤0.05) in the diabetic control group, compared with the corresponding value of normal control group. Supplementation with ketogenic diet only or ketogenic diet supplemented with different oils significantly decreased (P≤0.05) the elevated activity of both serum AST and ALT compared to the positive control group. Moreover, there is no significant difference in serum AST and ALT among the three treated groups with ketogenic diet supplemented with oils of either grape seed or fish or virgin olive.

Table (3): Effect of ketogenic diets on liver function of diabetic rats.

Parameters / Groups	AST	ALT
	(U/L)	
Control (-ve)	118.40 ±1.63^{d}	93.40 ±2.98^{d}
Control (+ve)	146.60±2.75^{a}	129.80±2.89^{a}
Diabetic+ keto diet	134.00 ±2.77^{b}	117.60±3.61^{b}
Diabetic+ keto diet (grape seed oil)	126.00 ±1.14^{c}	103.60±2.44^{c}
Diabetic+ keto diet (fish oil)	124.80±3.12^{cd}	101.40±2.56^{cd}
Diabetic+ keto diet (olive oil)	122.00±1.64^{cd}	107.20±3.06^{c}

Values were expressed as Means ± SE.
Values at the same column with different letters are significant at P≤0.05.

Table (4) illustrates the effect of ketogenic diet supplemented with different oils on kidney functions of diabetic rats. Injection with STZ significantly increase (P≤0.05) the level of urea and creatinine, compared to the control negative group. Feeding diabetic rats on ketogenic diet only or ketogenic diet supplemented with different oils caused a significant decrease (P≤0.05) in the mean values of urea and creatinine compared to the diabetic control group. No significant difference was noticed in serum urea and creatinine among the groups fed ketogenic diet supplemented with oils of either grape seed or fish or olive. Supplementation with different oils to the ketogenic diet significantly lowered the elevated level of creatinine compared to the diabetic rats that were fed on ketogenic diet only.

Table (4): Effect of ketogenic diets in serum urea and creatinine on diabetic rats

Parameters / Groups	Urea (mg/dl)	Creatinine (mg/dl)
Control (-ve)	33.20 ±1.28^{d}	0.35±.02^{d}
Control (+ve)	58.00 ±2.35^{a}	0.91±.03^{a}
Diabetic+ keto diet	43.20 ±1.07^{b}	0.73±.03^{b}
Diabetic+ keto diet (grape seed oil)	38.20±2.33^{bcd}	0.55 ±.04^{c}
Diabetic+ keto diet (fish oil)	37.20±1.39^{cd}	0.52±.05^{c}
Diabetic+ keto diet (olive oil)	40.20±1.66^{bc}	0.49±.05^{c}

Values were expressed as Means ± SE.

Values at the same column with different letters are significant at P≤0.05.

The impact of ketogenic diet only or ketogenic diet supplemented with oils of either grape seed or fish or olive on lipids profile of diabetic rats was illustrated in Table (5). STZ injection to rats caused a significant increase (P≤0.05) in most of serum lipid parameters, while serum HDL-C was significantly lowered, compared to the healthy rats. Ketogenic diet only and ketogenic diet supplemented with oils of either grape seed or fish or olive significantly decreased (P≤0.05) the mean value of serum TG, TC, LDL-C and VLDL-C, while serum HDL-C level was increased significantly, compared to the diabetic control group. It was obvious that, the treatments with ketogenic diet supplemented with oils of both fish and olive caused the highest beneficial effect in improving lipid profile in diabetic rats.

Table (5): Effect of ketogenic diets on serum lipids profile of diabetic rats.

Parameters / Groups	TG	TC	HDL-C	LDL-C	VLDL-C
	(mg/dl)				
Control (-ve)	121.40±2.73^{d}	101.20±2.35^{d}	51.60±1.63^{a}	25.32±1.39^{d}	24.28±0.55^{d}
Control (+ve)	221.40±1.81^{a}	207.80±2.87^{a}	41.20±3.26^{b}	122.32±2.88^{a}	44.28±0.36^{a}
Diabetic+keto diet	153.60±3.25^{b}	129.60±1.50^{b}	44.00±1.82^{b}	54.88±2.88^{b}	30.72±0.65^{b}
Diabetic+ keto diet (grape seed oil)	144.60±3.49^{c}	120.80±1.69^{c}	45.40±1.63^{ab}	46.48±3.57^{c}	28.92±0.70^{c}
Diabetic+keto diet (fish oil)	138.40±2.50^{c}	116.60±3.75^{c}	47.60±1.57^{ab}	41.32±2.94^{c}	27.68±0.50^{c}
Diabetic+keto diet (olive oil)	137.40±1.72^{c}	118.60±1.83^{c}	46.40±2.46^{b}	44.72±2.60^{c}	27.48±0.34^{c}

Values were expressed as Means ± SE.
Values at the same column with different letters are significant at P≤0.05.

Discussion:

Recently, the very low-calorie ketogenic diet has been highlighted in obesity management and its comorbidities **(Merra *et al.*, 2016)**. It is an effective way to lose weight, as they promote a non-atherogenic lipid profile, decreased insulin resistance and improved blood glucose levels **(Merra *et al.*, 2016 and Abbasi, 2018)**. On the basis of the results in the present study, KD showed an improvement in blood levels of glucose and insulin in diabetic rats, which is in agreement with previous studies **Abdurrachim *et al.* (2019)** who reported that KD lowered blood glucose and improved insulin levels. Moreover, **Hallberg *et al.* (2018) and Rosenbaum *et al.* (2019)** reported that the use of VLCKD resulted a significant decrease in the level of triglycerides, glucose and the degree of liver steatosis while improve insulin levels. Some studies on animals have also shown that the KD can prevent the development of diabetes using STZ in rats **(Al-Khalifa *et al.*, 2009 and Al-Khalifa *et al.*, 2011)**. Also, **Guo *et al.* (2020)** stated that the KD improved both glycemic control and insulin sensitivity while decreased the degree of obesity in diabetic mice.

Serum glucose was increased in diabetic rats, while after the administration of KD supplemented with different oils the blood glucose was reduced which may be due to the protection of ß-cells in pancreas to produce insulin that enhance glycogen synthase **(Choudhury *et al.*, 2017)**. These results are compatible with the results of **Irandoost *et al.* (2013)** who reported that consumption of grape seed oil (GSO) in overweight / obese women appears to enhance insulin sensitivity. On the other hand, there is no side effects

mentioned for the effect of GSO in experimental diabetic rats. Moreover, **Shaker *et al.* (2018)** who mentioned that GSO plays an important role in treating diabetes mellitus and complications.

Furthermore, fish oil supplementation to the KD results in restoring blood lipid and glucose levels compared with KD alone **(Zulyniak *et al.*, 2013)**. **Iizuka *et al.* (2018)** found that addition of FO to low-dose pioglitazone effectively improved signs of type 2 diabetes in aged mice. Moreover, **Parveen *et al.* (2019)** stated that vegetables and fish oils are potent antidiabetic agent and beneficial for the regulation of diabetes-related disorders such as hyperglycemia, dyslipidemia and kidney damage induced by STZ in type 2 diabetic rat model. **Hua *et al.* (2020) and Souza *et al.* (2020)** found that FO supplementation is effective in enhancing insulin sensitivity and glycemic control in patients with overweight / obese and T2DM.

Al Jamal and Ibrahim, (2011) and Yousaf *et al.* (2014) noticed that virgin olive oil improved lipid profiles and blood glucose levels in STZ-induced diabetic rats which is in agreement with the results of the present study. This is due to the ability of phenolic compounds and monounsaturated fatty acids such as oleic acid to decrease the concentration of blood sugar by raising insulin sensitivity in cells **(Alkhatib *et al.*, 2018)**. **Guasch-Ferre *et al.* (2015)** mentioned that VOO lowered the risk of T2DM by 40% in patients with a high CVD risk. Also, **Schwingshack *et al.* (2017) and Tsartsou *et al.* (2019)** showed that olive oil consumption can improve blood glucose and lipid profile in diabetic patients.

Regarding to liver enzymes, the results of this study showed that the STZ induced a significant increase in the activity of serum AST and ALT. But, KD supplemented with either GSO or FO or OO caused significant improvement in liver function. Several studies have reported that GSO has hepatoprotective properties, among them the study of **Khudair and Aldabaj, (2015) and Mokhtar *et al.* (2016)** noticed that the oral administration of GSO showed significant decreases in serum AST and ALT activities. **Ismail *et al.* (2016)** demonstrated that GSO exhibits protective effects on acute liver damage caused by CCL_4 in γ-irradiated rats. Also **Atasever *et al.* (2019)** reported that GSO reduced increased activities of liver enzymes because of its antioxidant properties.

Furthermore, results of the present study revealed that feeding diabetic rats with KD supplemented with FO restored the liver and kidney functions to normal. **Metwally *et al.*, (2011)** showed that FO may have therapeutic potentiality for improving hepatic and renal functions in rats. **Hassanen and Ahmed, (2015)** showed that treatment with FO, VOO and their combinations exhibited improvement in liver functions and reduced the severity of liver injury. These results may be attributed to the presence of omega-3 fatty acids

that have significant beneficial effects on liver regeneration. **Al-Okbi *et al.* (2018)** found that FO was the most effective treatment for improving AST and ALT.

Addition of virgin olive oil to the KD improved both kidney and liver functions which was in agreement with **Santangelo *et al.* (2016)** who demonstrated that extra‑virgin olive oil consumption significantly reduced fasting plasma glucose, preserved hepatic and renal tissue from damages in diabetic rats. **Lama *et al.* (2017) and Rezaei *et al.* (2019)** showed that VOO limits insulin resistance and improved liver function.

Yanarates *et al.* (2008) found that the grape seed proanthocyanidins extracts (GSPE), considerably reduced serum urea and creatinine of diabetic rats. These results are matched with our findings. Also, **Alshubaily *et al.* (2018)** showed that GSO restored liver and kidney functions. The hepatic and renal protective effect of GSO is probably due to its antioxidant properties. Moreover, **Albrahim and Robert, (2020)** reported that grape seed extract could serve as the basis for developing improved chemopreventive or therapeutic kidney injury strategies.

Furthermore, **Abd El-Azime *et al.* (2014)** showed that FO could have the potential to improve hepatic and renal functions in irradiated rats. **Wong *et al.* (2010) and Al-Okbi *et al.*, (2018)** found that FO supplementation substantially decreased serum creatinine levels in Type 2 DM patients. **Alazawi and Almahdawi, (2018)** found that using olive oil, it reduces the level of glucose and improve the health of the patient by repairing the damage in beta pancreatic cells, because of containing olive oil polyphenols it reduces the level of urea and maintains its normal level against changes in the body.

The results of this study showed that concentrations of TC, TG, LDL-C and VLDL-C in diabetic rats increased, while HDL-C decreased. This may be attributed to lipolysis in adipose tissue which in turn cause hyperlipidemia **(Liu *et al.*, 2019)**. Feeding rats on ketogenic diet and KD containing either GSO or FO or OO have led to further decrease in all lipid parameters except for HDL-C which increased non- significantly. This is consistent with the results of **Rosenbaum *et al.* (2019) and Abdurrachim *et al.* (2019)** who reported that KD lowered lipid profile. These results confirmed with **Ng *et al.* (2016)** who found that the KD decreased plasma triglyceride levels while increased serum HDL-c in mice. Moreover, **Asadi *et al.* (2010) and Kim *et al.* (2010)** mentioned GSO has an important role to play in improving the serum lipid profile. This results, along with that reported by **Javadi *et al.* (2014)** found that GSO could have beneficial effect on lowering LDL-c and triglyceride levels in diabetic rats. This results confirmed with **Ranjbar-Zahedani *et al.* (2015) and**

Mokhtar *et al*., (2016) who specifies that GSO is effective in reducing TC, TG and LDL-c and increasing HDL-c.

Hassanen and Ahmed, (2015) and Kaseb and Biregani, (2016) showed that treatment with FO, VOO lowered lipid profile. These results, along with that reported by **Wang *et al*. (2019) and Souza *et al*. (2020)** demonstrate that FO can boost the lipid profile in rats with or without type 2 diabetes by reducing TG, TC, LDL, VLDL, and mildly elevating HDL-c. Consistent with previous studies **Thilakavathi *et al*. (2019)** who reported that omega 3 fish oil is a strong hypo-cholesterolemic agent.

Khan *et al*., (2107); Alazawi and Almahdawi, (2018) and Tsartsou *et al*. (2019) showed that EVOO a reduction of 14-25% in plasma lipids with an increase of 8-12% in HDL-c, which concludes that EVOO is effective in reducing lipid profile levels in type 2 diabetic dyslipidemia. Also, **Simon *et al*. (2019)** indicates that replacing high fat diet with OO may recover normal blood cholesterol values due to the presence of monounsaturated fatty acids and antioxidants **(Alazawi and Almahdawi, 2018)**. Phenolic compounds in OO have also been related to increased levels of HDL-c **(Servili *et al*., 2013)**. **Memon *et al*. (2018)** reported that the natural remedies Phyto therapy such as OO plays an important part in the treatment of dyslipidemia and control the serum TC and TG levels in type – II diabetic patients.

Conclusions

A ketogenic diet (KD) is a viable and safe nutritional plan for diabetic patients especially when supplement with oils of either grape seed or fish and virgin olive. When consuming ketogenic diets, careful choice of foods that will provide the necessary micronutrients is of paramount importance. KD successfully improved homeostasis of glucose in diabetic rats. It was concluded that, KD is a healthy foods and adjuvant therapy for diabetes in the future.

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الملخص العربى

دراسة التحكم في نسبة جلوكوز الدم بواسطة النظام الغذائي الكيتونى المدعم بالزيوت المختلفة في الفئران المصابة بمرض السكرى من النوع الثاني

في السنوات الأخيرة ، كان هناك تركيز متزايد على النظم الغذائية الكيتونية المنخفضة جدًا فى الكربوهيدرات ، في حين يتم مناقشتها بشكل شائع ومعارضتها في كثير من الأحيان ، فمن الواضح أنها ناجحة كوسيلة لعلاج السمنة وفرط الدهون والسكرى على الأقل على المدى القصير إلى المتوسط. لذلك أجريت هذه الدراسة للتحقق من تأثير النظام الغذائي الكيتوني المدعم اما بزيت بذر العنب أوالسمك أوالزيتون البكر على الفئران المصابة بداء السكرى. تم استخدام عدد ٤٨ من ذكور الفئران التي تزن ٢٠٠ إلى ٢١٠ جم ، تم تقسيمهم الى مجموعتين رئيسيتين. تم الاحتفاظ بالمجموعة الرئيسية الأولى (ن = ٨) كمجموعة ضابطة سالبة ، المجموعة الرئيسية الثانية تم استخدام عدد ٤٠ من الفئران واستخدمت كمجموعة ضابطة موجبة تم حقنهم بمادة الاستربتوزوتين (٦٠ملجم/كجم من وزن الجسم) لاحداث السكرى، ثم قسمت هذه الفئران إلى خمس مجموعات فرعية .تم تغذية المجموعة الفرعية الأولى على النظام الغذائي الأساسي واستخدمت كمجموعة ضابطة موجبة ، في حين تم تغذية المجموعة الفرعية ٢ على النظام الغذائي الكيتوني فقط بينما تم تغذية المجموعات الفرعية من ٣ إلى ٥ على النظام الغذائي الكيتوني المدعم بنسبة ٤% اما بزيت بذر العنب أوالسمك أوالزيتون البكر على التوالي . بعد ٨ أسابيع ، تم ذبح الفئران وجمع عينات الدم للحصول على السيرم . اوضحت النتائج أن الفئران المعاملة بالاستربتوزوتين أظهرت انخفاض معنوي ($P\leq0.05$) في تركيز الأنسولين في الدم وزيادة مستويات الجلوكوز مقارنة بالفئران الطبيعية. ادى النظام الغذائي الكيتوني المدعم بزيت بذر العنب أوالسمك أوالزيتون البكر في تحسين النتائج البيوكيميائية الناتجة عن مرض السكرى .علاوة على ذلك ، أدى التدخل إلى إحداث تغييرات إيجابية في صورة دهون الدم وتحسين وظائف الكبد والكلى للفئران المعالجة مقارنة بالمجموعة الضابطة الموجبة. الخلاصة إن النظام الغذائي الكيتوني والكيتونى المدعم بزيت بذر العنب أوالسمك أوالزيتون البكر هو نظام غذائي واعد محتمل لمرضى السكرى.