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# Comparative study of some regime's efficiency and their effects on diabetic rats

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## ABSTRACT

The purpose of this study was to look at the efficacy and effects of various regimes on diabetic rats. The animals were fed a standard meal for seven days of acclimation. Diabetes was induced. The diabetic group was separated into five subgroups (each with eight rats). The first subgroup (1) was control positive suffering from diabetes fed on basal diet, whereas the other four subgroups were suffering from diabetes treated with Zero, Zone, Atkins, and Mediterranean diets, respectively.. Subgroup (1): Positive diabetic control group fed a basal diet. Subgroup (2): diabetic rats on a zero-calorie diet. Subgroup (3): diabetes rats fed the Zone diet. Diabetes rats on the Atkins diet were assigned to subgroup (4). Obese rats fed a Mediterranean diet were assigned to subgroup (6). The negative normal control group consumed a basal diet. The results indicated a significant decrease in ultimate body weight growth ($p \leq 0.05$)for all treated subgroups with high fat/low carbohydrates diets. Rats of subgroups treated with Zero and Atkins diets were the lowest weight followed by those in subgroup MD diet. The lowest cholesterol content was found in rats fed on Zero and Zone diets, while subgroup treated with Zero diet has the highest ALT. All treated subgroups fed in different diet have AST lower than control positive subgroup. Histopathological examination indicated improvement liver as well as cerebral cortex of brain of diabetic rats fed MD diet.

***Keywords*:** regime's efficiency, diabetic rats, Diabetic Zero diet, Zone diet, Atkins diet, Mediterranean diet.

## INTRODUCTION

Diabetes affected an estimated 422 million individuals worldwide in 2014, and the disease claimed the lives of 1.5 million people in 2012. Diabetes complications can cause heart attacks, strokes, blindness, renal failure, and lower limb amputations, among other long-term repercussions that have a substantial impact on quality of life. (Moxey *et al*., 2011; WHO, 2016).

The Mediterranean diet consists of eating more plant-based foods (vegetables, fruits, non-refined grains, legumes), moderate amounts of poultry and fish, and less meat (especially processed meat) and full-fat dairy products. Olive oil is the primary fat utilized in food preparation and consumption. The macronutrient distribution in the Mediterranean diet is 40%-45% of the total caloric value from carbs (low glycemic index), 25% from proteins (mostly from vegetable sources), and 30%-35% from lipids. (Marin-Alejandre *et al*., 2019).

According to Tura et al. (2010), the Zone Diet focuses heavily on protein intake. It consists of 30% protein, 30% fat, and 40% carbohydrates. This high protein diet is a weight-loss plan that promotes the consumption of protein-rich meals. There are several types of high protein diets. Adults attempting to lose and maintain weight should consume no more than 30% of total daily calories from fat and less than 7% from saturated fat, which is difficult or unattainable with many high protein diets. High protein diets may also limit the intake of vital carbohydrates and low-fat dairy products.

A low-carbohydrate diet high in fat is similar to a ketogenic diet (20-50 g/d of carbs or 10% total kcal) or a low-carbohydrate diet (less than 130 g/d of carbs or <26% total kcal). (McAuley *et al.*, 2004).

The Atkins diet is a low-carb, high-protein, ketogenic diet that is separated into four phases. The most restrictive level limits carbohydrate intake to 20 grams per day. Other phases allow for 25 to 90 g/day. Most nutritionists recommend approximately 300 g per day. The diet does not limit protein, fat, or calories, although many dieters report reduced hunger and caloric consumption. Several nutritional supplements are mentioned, such as vitamins and minerals, including antioxidants, trace minerals, and essential fatty acids (Feinman *et al.,* 2015).

Zero carbohydrate diet excludes dietary consumption of all carbohydrates (including dietary fiber) and suggests fat as the main source of energy with sufficient protein. Its macronutrient composition is zero CHO, 80% fat and 20% protein (Borghjid and Feinman, 2012). A no-carbohydrate diet may be ketogenic, which means it causes the body to enter ketosis by turning food fat and body fat into ketone bodies, which are then utilized to feed portions of the body that do not metabolize fat for energy, particularly the brain. It may contain animal-sourced foods and a high saturated fat intake, although this is not a requirement of the diet, which by definition simply restricts carbohydrate intake.
Low-carbohydrate diets for weight loss have recently gained popularity. Low-carbohydrate diets have been used for decades (Bilsborough and Crowe, 2003).

. Furthermore, Li and Heber (2020) stated that the ketogenic diet was initially created in the 1920s to treat diabetes and pediatric epilepsy. It is now linked to weight loss and improved blood glucose management in patients with prediabetes and type 2 diabetes.
The Mediterranean diet is commonly regarded as a healthy eating pattern, with shown benefits for obesity treatment and reductions in related cardiovascular risk indicators (Lopez-Legarrea et al., 2014).

Reducing dietary carbohydrate as a diabetes treatment has been used both before and after insulin was discovered (Feinman et al., 2015). Low-carbohydrate diets have various acute benefits, including quick weight loss, decreased fasting glucose and insulin levels, lower circulating triglyceride levels, and improved blood pressure (Adam-perrot et al., 2006On the other hand, Itsiopoulos et al. (2011) discovered that a conventional moderate-fat Mediterranean diet improved glycemic control and diet quality in men and women with well-controlled type 2 diabetes without having a detrimental effect on weight. An analysis of modern Western diets—the American, Mediterranean, Atkins, and Zone diets—reveals the conflicts that exist about the optimal and healthy approach to human nutrition and proposes a "return to Nature" (Gasbarrini and Piscaglia 2005).

The current study comparing between using different diets (basal, Zero, Zone, Atkins and Mediterranean diets) for reduction of weight of diabetic rats.

## MATERIALS AND METHODS

### Materials:

### Chemicals and kits:

El-Gomhoryia Company in Cairo, Egypt, supplied casein, vitamins, minerals, and alloxan. The additional biochemical kits were bought from EGYPTLAB Company in Egypt.

### Animals:

48 adult male white albino rats (Sprague Dawley strain) weighing an average of 150±2g were obtained from Egypt VACSERA Company in Helwan, Egypt.

### Method

### Induction of diabetes and Experimental design:

Rats were fed a standard diet for 7 days to acclimatize. A single dosage of 200 mg/kg body weight of alloxan monohydrate in freshly produced 10 mmol/L sodium citrate, pH 4.5, was administered intraperitoneally (IP) to rats fasting for at least 10 hours after glucose.loading/2 days.
Blood sugar levels were assessed three days before and seven days after induction. Diabetes mellitus was diagnosed with sustained hyperglycemia (>11.11mmol/L or ≥200 mg/dL) using the approach outlined by Srinivasan and Kaul (2005).The diabetic group was separated into five subgroups (each with eight rats). The first subgroup consisted of control positive diabetics fed a basal diet, whereas the other four categories were diabetics treated with the Zero, Zone, Atkins,

and Mediterranean diets.Group negative: negative control group fed on basal diet.
Subgroup (1): positive diabetes control group fed on basal diet.
Subgroup (2): diabetes rats treated with Zero diet.
Subgroup (3): diabetes rats treated with Zone diet.
Subgroup (4): diabetes rats treated with Atkins diet.
Subgroup (5): obese rats treated with Mediterranean diet.

**Blood sampling:**

At the conclusion of the trial (6 weeks), all rats were starved overnight and anesthetized. Blood samples were taken from the hepatic portal vein into a clean, dry centrifugation tube, and serum was separated by centrifugation for 15 minutes at 3000 rpm at room temperature and kept frozen at -20°C until analysis..

**Biological evaluation:**

During the trial, the amount of diet ingested and/or wasted was documented every day. In addition, the rat's weight was measured weekly to assess feed intake, body weight gain percentage, relative organ weight, and feed efficiency ratio using the Chapman et al. (1959) calculations.
BWG% = [(Final weight - Initial weight)/Initial weight]. X100
FER = [body weight gain (g) / dry feed consumed (g)] X100

**Biochemical analysis**

**Assessment of serum glucose:**

Serum glucose levels were measured using colorimetric process kits produced by Diamond Diagnostics Kits Cairo, Egypt at 550 n/m, as described by Trinder (1969).

**Assessment of lipid profile**

The fully enzymatic measurement of total triglycerides in serum was estimated spectrophotometrically at 500 n/m using Wahlefed's (1974) Stanbio kits for triglyceride hydrolysis. Enzymatic cholesterol determination was performed using the methods of Allian et al. (1974), with kits acquired from Stanbio (Texas, USA), and HDL-c was provided by Stanbio, Lab. Inc. Texas. According to Warnick et al. (1983), Low-density lipoprotein (LDL-c) and very low-density lipoprotein (VLDL-c) cholesterol were precipitated from serum using magnesium chloride/dextran sulfate reagents. According to Friedewald et al. (1972), high-density lipoprotein (HDL-c) cholesterol was measured in the supernatant using cholesterol reagent, and LDL-c was calculated as the difference between total cholesterol, HDL-c cholesterol, and triglyceride. Calculation: LDL = Total cholesterol - [HDL-(Triglycerides/5)].
VLDL cholesterol (mg/dL) = TG/5

**Assessment of serum Kidney function and some liver enzymes:**

Garaway's (1980) method for estimating uric acid was used. Serum creatinine was measured using the method given by Bohmer (1971). Serum urea nitrogen was measured using the method given by Kaplan (1984). The activity of alkaline phosphatase (ALP) in plasma was measured using the Kind and King technique (1954). Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels were measured calorimetrically using the method described by Reitman and Frankel (1957).

**Assessment of adiponectin and leptin**

Serum adiponectin and leptin concentrations were determined using a commercially available ELISA test (B-Bridge International, Inc, Sunnyvale CA, USA and R&D System, Minneapolis MN, USA, respectively) according to Shimizu et al. (1997). The hormones were determined in El-Demerdash Hospital's main laboratory at Ain Shams University.

**Histological examination**

Liver and brain were removed, wiped on filter paper, and weighed separately. After 6 weeks, tissue specimens from treated and control rats were submerged in 10% neutral buffered formalin for 24-48 hours. The fixed tissues were rinsed in tap water, dehydrated, exposed to rising ethanol concentrations ranging from 60% to 100%, cleaned in xylene, and embedded in paraffin blocks in accordance with Carleton et al. (1967).

**Statistical Analysis:**

A p-value $< 0.05$ was considered statistically significant for unpaired data using a t-test between two means or an LSD's multiple range test using Statistical Package for the Social Sciences (SPSS) posteriori analysis of variance (ANOVA) among three

means. All values are expressed as mean ± SD. (Steel and Torri, 1980).

## RESULTS AND DISSECTIONS

### Feed Intake and Body weight gain:

The results in Table (1) showed that the feed intake for subgroup MD diet records the highest feed intake (11.42±2.75), while the lowest feed intake was in subgroup Atkins diet (3.50±0.89) and the difference showed highly significant ($p \leq 0.05$). On the other hand, there was significant ($p \leq 0.05$) between control group and other positive subgroups under investigate. Also, it was obvious that the negative feed efficiency ratio **(**FER) values across all diabetic subgroups .

The Zone diet (subgroup 3: FER = -0.093) and MD diet (subgroup 5: FER = -0.112) showed less severe metabolic disruption than Zero (subgroup 2: FER = -0.303) and Atkins (subgroup 4: FER = -0.365). This may be due to the Zone diet's balanced macronutrient profile (40% carbohydrates, 30% protein, 30% fat) and the MD diet's anti-inflammatory effects (Estruch et al., 2018).

Table (1) shows a substantial decrease in end body weight gain ($p \leq 0.05$) for all treatment subgroups with high fat/low carb diets.The subgroups fed Zero and Atkins diets had the lowest weight among subgroups then MD diet. This result agrees with Krebs *et al.* (2013) and Zhang *et al.* (2018).

**Table (1): The effect of different high fat/low carbohydrates diets on final weight and FER for rats suffering from diabetes (M± SD).**

| Parameters / Groups/Subgroups | Initial weight (g) | Final weight (g) | feed intake (g) | BWG (%) | Feed efficiency (Ratio) |
|---|---|---|---|---|---|
| Control (-ve) | 220.88±0.55$^{a}$ | 189±3.8$^{b}$ | 8.54±0.67$^{a}$ | 12.27±1.46$^{b}$ | 0.089±0.10$^{b}$ |
| Subgroup 1: Diabetic (+ve) | 220.63±2.93$^{a}$ | 216.88±3.35$^{a}$ | 12.32±0.85$^{a}$ | 2.27±0.30$^{c}$ | 0.008±0.03$^{c}$ |
| Subgroup 2: Diabetic fed Zero diet | 224±1.54$^{a}$ | 176±2.6$^{b}$ | 3.79±0.45$^{b}$ | -21.04±2.80$^{a}$ | -0.303±0.13$^{a}$ |
| Subgroup 3: Diabetic fed Zone diet | 219.75±3.93$^{a}$ | 179±3.51$^{b}$ | 10.69±1.46$^{a}$ | -18.52±2.08$^{a}$ | -0.093±0.03$^{b}$ |
| Subgroup 4: Diabetic fed Atkins diet | 222.25±3.45$^{a}$ | 176.63±2.67$^{b}$ | 3.50±0.89$^{b}$ | -19.45±1.87$^{a}$ | -0.365±0.45$^{a}$ |
| Subgroup 5: Diabetic fed MD diet | 222.75±4.41a | 171.0±1.37b | 11.42±2.75$^{a}$ | -21.91±1.28a | -0.112±0.08a |

Column with different letters means that is significant difference at ($p \leq 0.05$).

### Serum blood sugar:

The data in Table (2) demonstrated that the control positive diabetic subgroup had higher blood sugar levels than the control negative group. Diabetic segments treated with a high fat diet had significantly lower serum blood sugar levels ($p \leq 0.05$) compared to the positive diabetic subgroup. This could be attributed to weight loss, which leads to a decrease in blood sugar and insulin. These findings were consistent with Hussain *et al*. (2012), Krebs *et al.* (2013), and Sumithran *et al*. (2013).

**Table (2): The effect of different high fat/ low carbohydrates diets on blood sugar function for rats suffering from diabetes (M± SD).**

| Parameters / Groups/Subgroups | Blood sugar (mg/dl) | % of decrement than positive group |
|---|---|---|
| Control (-ve) | 55.48±2.89$^{d}$ | ---- |
| Subgroup 1: Diabetic (+ve) | 350.00±2.21$^{a}$ | ---- |
| Subgroup 2: Diabetic fed Zero diet | 124.75±1.32$^{c}$ | 64.38% |
| Subgroup 3: Diabetic fed Zone diet | 135.63±1.29$^{c}$ | 61.25% |
| Subgroup 4: Diabetic fed Atkins diet | 104.14±2.49$^{b}$ | 70.25% |
| Subgroup 5: Diabetic fed MD diet | 106.50±1.96$^{b}$ | 69.57% |

Column with different letters means that is significant difference at ($p \leq 0.05$).

**Lipid profile:**

Table (3) shows that the control positive diabetic subgroup has higher total cholesterol, triglycerides, LDL-c, and VLDL-c levels than the control negative group (healthy group).This result agreed with the previous data which confirmed that Diabetic rats exhibit greater levels of total cholesterol, triglycerides, LDL-C, VLDL-C, and decreased HDL. (Aclan, 2014). Diabetic subgroups treated with Zero, Zone and Atkins diets have triglyceride higher than the control positive diabetic subgroup. Even, There were statistically significant differences ($p \leq 0.05$) between treated diabetic subgroups and control positive diabetic groups .On contrast diabetic subgroup treated with MD diet has triglycerides close to the control negative group. These result not agree with Alnasir and Fateha (2003) who reported no significant change in triglyceride during adhere low carbohydrate diet, also not agree with Farnsworth *et al,* (2003) who mentioned that HP diet reduction triglycerides. From the results, the cholesterol rate increased for the treated groups compared to the positive group, except the MD group, which showed a significant decrease in the cholesterol rate compared to the other experimental subgroups. It should be noted that, the lowest cholesterol content was found in rats fed on Zero and Zone diet this result agreed with Zhang *et al.* (2016).

All treated diabetic subgroups fed in different diets have HDL-c higher than the control positive diabetic subgroup.On the other side, the control negative group had the highest score. There were no statistically significant differences ($p \leq 0.05$) identified among all treated diabetics. subgroups and the control positive diabetic subgroup. These result agreed with Dashti *et al.* (2007).

Diabetic subgroups treated with Zero, Zone and Atkins diets have LDL-c lower than the control positive diabetic group and there were no significant at ($p \leq 0.05$), on contrast diabetic subgroup treated with MD has the lowest LDL-c, and approximately like control negative group. LDL-c level was statistically significant at ($p \leq 0.05$) between treated diabetic subgroups with MD diet and the control positive group. These result does not agree with Parker *et al.* (2002) who showed The lowering of LDL cholesterol in both sexes on the HP diet suggests that it is a valid diet choice for reducing CVD risk in type 2 diabetes. The lowering of LDL cholesterol in both sexes on the HP diet suggests that it is a valid diet choice for reducing CVD risk in type 2 diabetes, but agreed with Wang *et al.* (2003) and Hernaez *et al*. (2017). Meanwhile, diabetic subgroups treated with Zero, Zone and Atkins diets have VLDL.c levels higher than the control positive diabetic subgroup. Diabetic subgroups treated with MD diet have VLDL.c levels close to the control negative group and there was statistical difference between them. On contrast diabetic subgroup treated with MD diet has the lowest VLDL.c.

**Table (3): The effect of different high fat/ low carbohydrates diets on lipid profile suffering from diabetes (M± SD).**

| Parameters / Groups/Subgroups | Triglycerides (mg/dl) | Total cholesterol (mg/dl) | HDL-C (mg/dl) | LDL-C (mg/dl) | vLDL (mg/dl) |
|---|---|---|---|---|---|
| Control (-ve) | 66.29±3.99$^{b}$ | 96.0±2.45$^{b}$ | 58.07±2.91$^{a}$ | 24.70±3.22$^{b}$ | 13.23±0.80$^{b}$ |
| Subgroup 1: Diabetic (+ve) | 77.13±2.30$^{b}$ | 114.72±2.33$^{a}$ | 42.25±2.25$^{b}$ | 57.04±2.08$^{a}$ | 15.43±0.46$^{b}$ |
| Subgroup 2: Diabetic fed Zero diet | 109.50±1.43$^{a}$ | 120.13±3.56$^{a}$ | 45.63±1.55$^{b}$ | 52.60±2.78$^{a}$ | 21.90±1.49$^{a}$ |
| Subgroup 3: Diabetic fed Zone diet | 105.91±1.95$^{a}$ | 123.18±2.86$^{a}$ | 47.41±1.15$^{b}$ | 54.59±2.81$^{a}$ | 21.18±0.79$^{a}$ |
| Subgroup 4: Diabetic fed Atkins diet | 102.31±1.62$^{a}$ | 121.35±2.65$^{a}$ | 45.13±1.45$^{b}$ | 55.76±2.14$^{a}$ | 20.46±0.72$^{a}$ |
| Subgroup 5: Diabetic fed MD diet | 65.40±2.22$^{b}$ | 82.24±1.51$^{c}$ | 46.50±3.86$^{b}$ | 22.66±1.21$^{b}$ | 13.08±0.44$^{b}$ |

Column with different letters means that is significant difference at ($p \leq 0.05$).

**Serum liver functions:**

The results in Table (4) revealed that control positive diabetic subgroup has AST higher level than control negative group. All treated diabetic subgroups fed in different diet have AST lower than diabetic control positive subgroup. The amount of AST in the subgroup treated with the Zero diet was similar to the control negative group, with no statistical difference identified between them.While AST level in diabetic subgroups treated with Zone, Atkins and MD diets have been dramatically decreased compared to the diabetic control positive subgroup.. The result revealed that control positive diabetic subgroup tended to have ALT higher than control negative group. All treated subgroups fed in different diets have AST lower than the control positive diabetic subgroup. AST levels in diabetic subgroups treated with Zone, Atkins, and MD diets reduced significantly ($p \leq 0.05$) compared to the control negative group.46.50±3.86$^{b}$ On contrast diabetic subgroup treated with Zero diet has the highest ALT, may be due to the regimes contain a lot of fat and protein, these result agree with Zhang *et al.* (2018).

However, the results revealed that The control positive diabetes subgroup had greater ALP levels than the control negative group, which fell considerably ($p \leq 0.05$) in treated diabetic groupings with Zone. Atkins and MD diets. On contrast diabetic subgroup treated with Zero diet has the highest ALP. A high fat diet may cause fatty liver. and promote inflammations, these results agreed with Fraser *et al.* (2008) and Moosavian *et al.* (2019).

**Table (4): The effect of different high fat/ low carbohydrates diets on liver function for rats suffering from (M± SD).**

| Parameters / Groups/Subgroups | AST *(U/L)* | ALT *(U/L)* | ALP *(U/L)* |
|---|---|---|---|
| Control (-ve) | 69.00±0.68$^{e}$ | 46.25±0.47$^{e}$ | 79.75±1.025$^{d}$ |
| Subgroup 1: Diabetic (+ve) | 187.75±2.97$^{a}$ | 104.50±2.28$^{b}$ | 124.63±2.58$^{a}$ |
| Subgroup 2: Diabetic fed Zero diet | 171.25±2.99$^{a}$ | 298.75±2.32$^{a}$ | 98.63±2.93$^{c}$ |
| Subgroup 3: Diabetic fed Zone diet | 160.88±3.21$^{b}$ | 67.74±0.38$^{d}$ | 99.63±2.68$^{b}$ |
| Subgroup 4: Diabetic fed Atkins diet | 135.0±2.40$^{c}$ | 81.14±1.32$^{c}$ | 74.13±1.92$^{f}$ |
| Subgroup 5: Diabetic fed MD diet | 114.50±2.63$^{d}$ | 66.48±1.76$^{d}$ | 75.88±1.19$^{e}$ |

Column with different letters means that is significant difference at ($p \leq 0.05$).

**Serum kidney functions:**

The data present in Table (5) showed that the control positive diabetic subgroup has serum urea higher than that of the control negative group. Levels of serum urea in diabetic subgroups treated

with Zero and Zone diets increased significantly at ($p \leq 0.05$) compared to the control positive diabetic subgroup. There were no significant in levels of serum urea between Atkins, MD diets diabetic subgroups and the diabetic control positive subgroup. The results showed that control positive diabetic subgroup tends to have uric acid levels higher than the control negative group. On the other hand, uric acid levels of subgroups treated with Zero, Atkins and MD diets decreased significantly compared to the control positive diabetic subgroup. While uric acid levels of diabetic subgroup treated with Zone diet was close to the control positive diabetic subgroup. These results agreed with Chauveau *et al.* (2018) who showed favorable effects of MD diet on reducing renal function.

For creatinine, the results revealed that the control positive diabetic subgroup was higher than that in the control negative group. Creatinine level in all treated diabetic subgroups decreased significantly at (($p \leq 0.05$) as compared to the control positive diabetic subgroup. These results disagreed with Suyoto (2018) who showed no effect on marker of renal function after provision of LCD and also disagreed with Johnston *et al.* (2004) who reported HP diet reduced uric acid and no change in creatinine.

**Table (5): The effect of different high fat, low carbohydrates diets on kidney function for rats suffering from diabetes (M± SD).**

| Parameters / Groups/Subgroups | Serum urea (ml/dl) | Uric acid (ml/dl) | Creatinine (ml/dl) |
|---|---|---|---|
| Control (-ve) | 40.75±1.11$^{c}$ | 1.73±0.32$^{b}$ | 0.67±0.11$^{b}$ |
| Subgroup 1: Diabetic (+ve) | 65.46±2.49$^{b}$ | 2.64±0.47$^{a}$ | 1.29±0.24$^{a}$ |
| Subgroup 2: Diabetic fed Zero diet | 70.70±2.75$^{a}$ | 1.78±0.39$^{b}$ | 0.64±0.05$^{b}$ |
| Subgroup 3: Diabetic fed Zone diet | 73.24±3.10$^{a}$ | 2.16±0.33$^{a}$ | 0.578±0.13$^{b}$ |
| Subgroup 4: Diabetic fed Atkins diet | 60.81±3.52$^{b}$ | 1.71±0.28$^{b}$ | 0.458±0.08$^{b}$ |
| Subgroup 5: Diabetic fed MD diet | 60.53±1.95$^{b}$ | 1.78±0.24$^{b}$ | 0.465±0.05$^{b}$ |

Column with different letters means that is significant difference at ($p \leq 0.05$).

**Serum blood leptin and adiopnectin hormones:**

The data in Table (6) demonstrated the effect of varied high fat/low carbohydrate diets on blood leptin and adiponectin. The results showed that, control positive diabetic subgroup has leptin hormone higher than the control negative group while, The positive diabetic control subgroup had lower adiponectin hormone levels than the control negative group (healthy group).The results of leptin hormone for treated diabetic subgroups with Zero, Zone, Atkins and MD diets indicated substantial decrease ($p \leq 0.05$) compared to the positive control diabetes group.. Leptin plays a key role in energy metabolism. Higher plasma leptin levels were initially found to be associated with diabetes. These results agree with Jonsson *et al.* (2010). Adiopnectin levels significantly rose ($p \leq 0.05$) in diabetic subgroups treated with Zero, Zone, Atkins, and MD diets compared to the positive diabetic control subgroup, but were comparable to the negative control group. Adiponectin inhibits anti-atherogenic and anti-inflammatory activities. It may also have significant clinical benefits in terms of developing medicines for the prevention and/or treatment of obesity and obesity-related diabetes.these result agreed with Lasa *et al.* (2014).

**Table (6): The effect of different high fat/ low carbohydrates diets on leptin and adiponectin hormones for rats suffering from diabetes (M± SD).**

| Parameters / Groups/Subgroups | Leptin (µg/ml) | Adiponectin (µg/ml) |
|---|---|---|
| Control (-ve) | $0.812 \pm 0.212^{c}$ | $131.12 \pm 0.22^{a}$ |
| Subgroup 1: Diabetic (+ve) | $3.236 \pm 0.092^{a}$ | $102.61 \pm 0.26^{b}$ |
| Subgroup 2: Diabetic fed Zero diet | $0.991 \pm 0.26^{b}$ | $122.18 \pm 0.36^{a}$ |
| Subgroup 3: Diabetic fed Zone diet | $0.923 \pm 0.30^{b}$ | $125.92 \pm 0.31^{a}$ |
| Subgroup 4: Diabetic fed Atkins diet | $1.02 \pm 0.16^{b}$ | $126.19 \pm 0.28^{a}$ |
| Subgroup 5: Diabetic fed MD diet | $0.919 \pm 0.12^{b}$ | $130.16 \pm 0.36^{a}$ |

Column with different letters means that is significant difference at ($p \leq 0.05$).

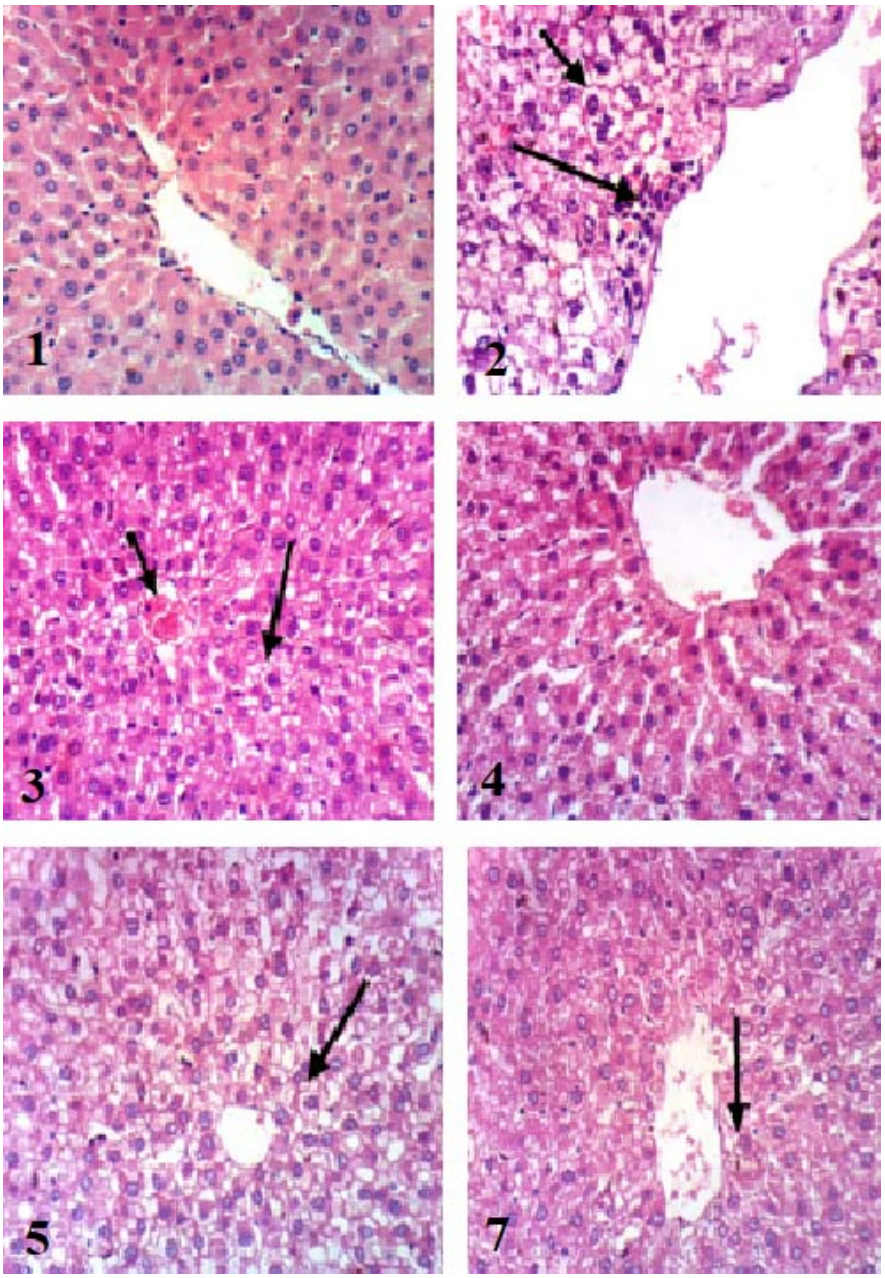
**Histopathological examination:**

**Liver:**

The liver of rats from the negative control group showed normal histological structure of hepatic lobules (Figs. 1). While the liver of rats in the positive diabetes control group showed congestion of the central vein, hydropic degeneration of hepatocytes, and focal necrosis of hepatocytes associated with inflammatory cell infiltration (Fig. 2), the liver of rats on the zero diet showed congestion of the central vein and cytoplasmic vacuolization of hepatocytes. However, slices from the Zone diet group exhibited obvious normal hepatocytes with no histological alterations (Fig. 4).. On the other hand, the liver of rats on the Atkins diet showed minor cytoplasmic vacuolization of hepatocytes (Fig. 5). Furthermore, the liver from the MD diet group showed no histological alterations other than mild cytoplasmic vacuolization of certain hepatocytes (Fig. 6); these findings contradict Ulusoy and Eren (2008) but accord with Zang *et al.* (2018).

**Brain:**

Microscopically, the brain (cerebral cortex) of rats from the negative control group showed no histological alterations. While the brain of rats in the positive diabetes control group displayed necrosis, pyknosis, and neuronal atrophy (Fig. 8). However, the brains of rats in the Zero diet group showed necrosis of certain neurons and neuronophagia (Fig. 9). certain investigated slices from the Zone diet group revealed necrosis of certain neurons (Fig. 10). Furthermore, the brains of rats fed the Atkins diet showed necrosis of certain neurons (Fig. 11). A marked improvement was observed in the brains of rats fed the MD diet, as analyzed sections exhibited necrosis of sporadic neurons (Fig. 12).




**Figures (1-6): Sections of liver of experimental rats. Stained with (H & E), X 400.**

**Fig. (1): Negative control group showing the normal histological structure of hepatic lobules.**

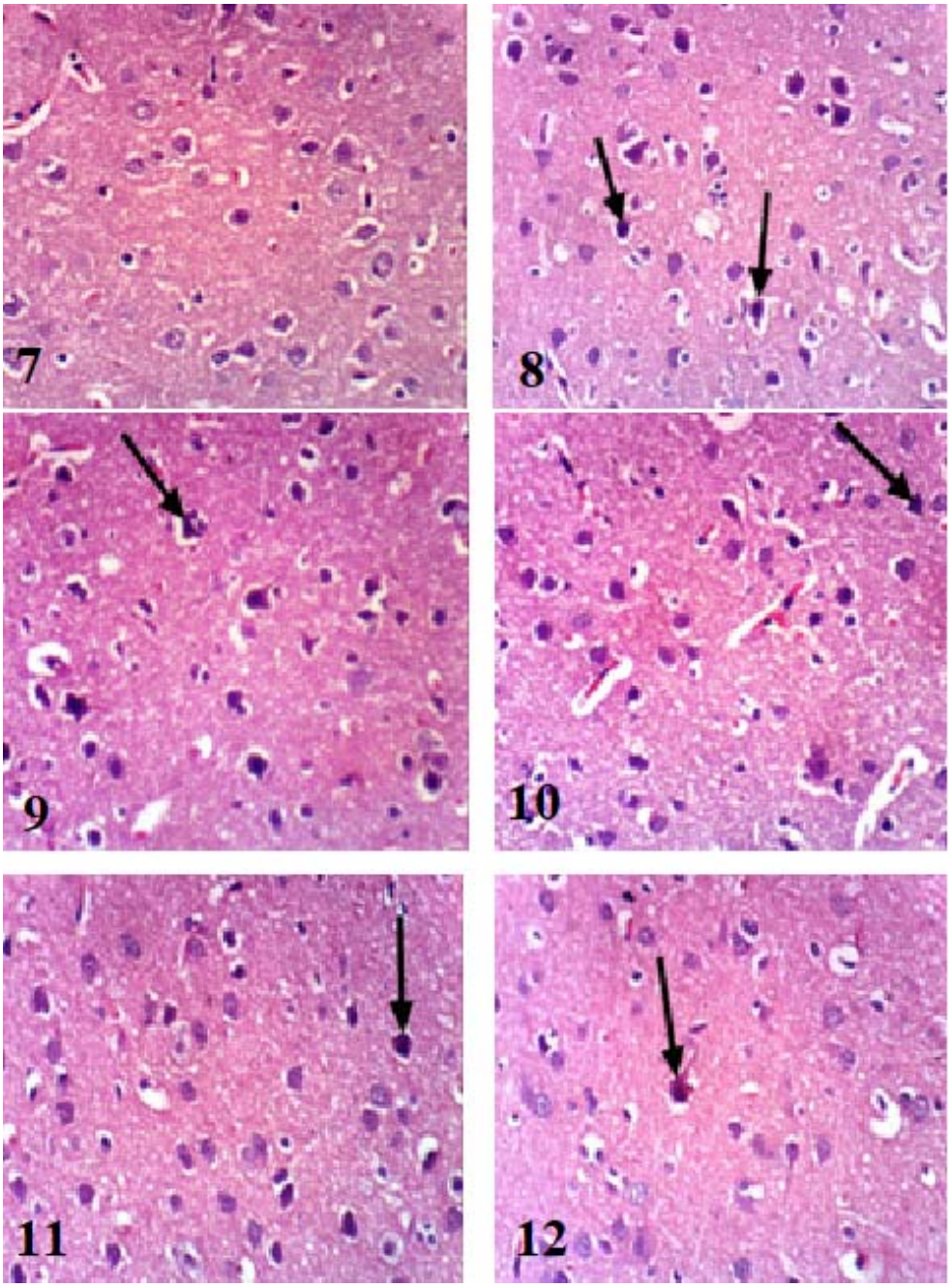
**Fig. (2): Diabetic +ve control subgroup (1) showing hydropic degeneration of hepatocytes and focal necrosis of hepatocytes associated with inflammatory cells infiltration.**

**Fig. (3): Diabetic subgroup (2) treated with Zero diet showing congestion of central vein and cytoplasmic vacuolization of hepatocytes.**

**Fig. (4): Diabetic subgroup (3) treated with Zone diet showing apparent normal hepatocytes.**

**Fig. (5): Diabetic subgroup (4) treated with Atkins diet showing slight cytoplasmic vacuolization of hepatocytes.**

**Fig. (6): Diabetic subgroup (2) treated with MD diet showing slight cytoplasmic vacuolization of some hepatocytes.**




**Figures 7-12): Sections of Brain (cerebral cortex) of experimental rats. Stained with (H & E), X 400.**

**Fig. (7): Negative control group showing the normal histological structure of cerebral cortex of brain.**

**Fig. (8): Diabetic +ve control subgroup (1) showing necrosis, atrophy and pyknosis of neurons.**

**Fig. (9): Diabetic subgroup (2) treated group with Zero diet showing necrosis of some neurons and neuronophagia.**

**Fig. (10): Diabetic subgroup (3) treated with Zone diet showing necrosis of some neurons**

**Fig. (11): Diabetic subgroup (4) treated with Atkins showing necrosis of some neurons.**

**Fig. (12 Diabetic subgroup (3) treated with MD diet showing necrosis of sporadic neurons.**

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# Comparative study of some regime's efficiency and their effects on diabetic rats

## دراسة مقارنة لكفاءة بعض الأنظمة الغذائية وتأثيراتها على الفئران المصابة بداء السكري

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**المستخلص**

اجريت هذة الدراسة لتقييم كفاءة بعض الانظمة الغذائية وتاثيرها على الفئران المصابة بالسكرى . تم تغذية الحيوانات على نظام غذائى طبيعى لمدة 7 ايام من التاقلم. تم احداث مرض السكرى وقسمت المجموعات التى تعانى من مرض السكرى الى 5 مجموعات فرعية (ن- 8 فئران فى كل مجموعة). كانت المجموعة الفرعية الاولى هى المجموعة الضابطة الايجابية التى تعانى من مرض السكرى وتتغذى على نظام غذائ اساسى وكانت المجموعات الفرعية الاخرى المكونة من مرض السكرى المعالج بنظام زيرو و زون و اتكيز والنظام الغذائى المتوسطى على التوالى: مجموعة ضابطة سلبية (1) تتغذى على نظام غذائى اساسى. المجموعة الفرعية (2) : مجموعة ضابطة ايجابية لمرض السكرى تتغذى على نظام غذائى اساسى . المجموعة الفرعية (3): فئران مصابة بالسكرى تتغذى على نظام زيرو الغذائى. المجموعة الفرعية (4):فئران مصابة بالسكرى تتغذى على نظام زون الغذائى. المجموعةالفرعية (5):فئران مصابة بالسكرى تتغذى على نظام اتكينز الغذائى المجموعة الفرعية (6): فئران سمينة تتغذى على النظام الغذائى المتوسطى. اظهرت النتائج ان زيادة وزن الجسم النهائية قد انخفضت بشكل ملحوظ لجميع المجموعات المعالجة بنظام غذائى عالى الدهون/منخفض الكربوهيدرات. كانت المجموعات المعالجة بنظامى زيرو واتكينز هى الاقل وزنا بين المجموعات ثم نظام MD . تم العثور على اقل محتوى للكوليسترول فى الفئران التى تغذت على نظام زيرو وزون, المجموعة المعالجة بنظام زيرو لديها اعلى مستوى لانزيم الانين امينو ترانسفيراز, جميع المجموعات المعالجة التى تغذت على نظام غذائى مختلف كان مستوى انزيم الانين امينو تراسفيراز اقل من المجموعة الايجابية الضابطة . أشار الفحص النسيجي إلى تحسن وظائف الكبد وكذلك القشرة المخية للفئران المصابة بمرض السكري والتي تغذت على نظام غذائي يحتوي على MD.

**الكلمات المفتاحية**: فعالية النظام الغذائي، الفئران المصابة بمرض السكري، نظام زيرو الغذائى ، نظام زون، نظام أتكينز، النظام الغذائى .