

## **Antidiabetic and Antiatherosclerotic activity of dried red radish roots (*Raphanus sativus L*) on hypercholesterolemic diabetic rats**

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### **ABSTRACT**

**T**his study was performed to assess the hypoglycemic and Antiatherosclerotic effects of dried red radish roots on hypercholesterolemic diabetic rats. Red radish roots contained good quantities of bioactive compounds as phenolic compounds, flavonoids and anthocyanin also its antioxidant activity. Rats were randomly divided into two main groups, the first group is normal control, and the second is the hypercholesterolemic diabetic rats which were divided into four subgroups (8 rats each) as follow: subgroup 1 served as positive control group, subgroup 2, 3 and 4 were fed on the diet containing 2.5%, 5% and 7.5% of dried red radish roots powder for 6 weeks respectively. After completing the treatment period, blood samples were collected for used to the biochemical analysis as blood glucose, insulin and lipid profile. Heart were taken for aortic histopathological. The results indicated that treatments with dried red radish roots significantly decreased the levels of blood and urine glucose, lipid profile, hepatic lipid and atherogenic indices compared to positive control group and improved the level of insulin and histopathological changes in the aorta of hypercholesterolemic diabetic rats. In conclusion, red radish roots as a source of antioxidant compounds had hypoglycemic effect, improved lipid metabolism and prevent cardiovascular diseases.

**Keywords:** red radish roots - atherogenic indices - antidiabetic activity - hypercholesterolemic diabetes rats.

## INTRODUCTION

Diabetes and cardiovascular disease are the major causes of morbidity and mortality. Epidemiological studies suggested that the risk factors for cardiovascular disease and diabetes include hypercholesterolemia and hyperglycemia, which are largely influenced by diet (**Kaur et al., 2002 and Turlouki et al., 2009**). Diabetes mellitus (DM), a heterogeneous metabolic disorder, is an increasing worldwide health problem and manifests hyperglycemia and other symptoms (**Kawamori, 2002**). DM is associated with premature and accelerated atherosclerosis (**Tomkin, 2010**). The overall risk of cardiovascular disease (CVD) for people with DM increases two- to three fold in men, and three to five fold in women when compared to people without DM (**Standl et al., 2009**). Depending on the assessment methodology, approximately 50– 70% of all people with DM (both type 1 and type 2), die due to CVD (**Standl et al., 2009**). Diabetic

complications correlate with hyperglycemic levels and also with length of exposure to hyperglycemia. Both type 1 and type 2 of diabetes mellitus are associated with accelerated atherosclerosis. Strong epidemiological evidence supports an association between glycemic control and CVD risk (**Prince et al., 2007**).

Laboratory and clinical studies have shown that a diet supplemented with fruit and vegetables had beneficial effects on diabetes and atherosclerosis (**Adams et al., 2006; Bazzano et al., 2008 and Mirmiran et al., 2009**). Radish is commonly cultivated in the world for its edible roots. The most common radish cultivars are the well-known red varieties, while other varieties vary in size, color (**Gutierrez and Perez 2004; Hara et al., 2009**). Its fresh roots can be cooked or processed by pickling or drying. Radish contains very potent phytochemicals, glucosinolates, (**Mithen et al., 2010**). And high content of flavonoids, including anthocyanins (**Lin et al.,(2011) and Tamura et al. 2010**). Also radishes are rich in ascorbic

acid, folic acid, vitamin B6, riboflavin, potassium, magnesium, copper, and calcium (Jan and Badar, 2012). The radish has been used in some societies as a laxative, stimulant, digestive acid, appetizer, and to treat stomach disorders (Gilani and Ghayur 2004). Also Curtis, (2003) suggested that radish can be used as an alternative treatment for various ailments including hyperlipidemia, coronary heart diseases, cancer. Therefore the present study investigated the influence of dried red radish roots to improve diabetic parameters, lipid profile and atherogenic indices in hypercholesterolemic diabetic rats.

## **MATERIALS & METHODS**

### **Materials:**

**Fresh red radish roots:** Fresh red radish roots (*R. Sativus*) vegetables were purchased from a local market (Shiben El-Kom, El- Menoufia, Egypt).

**Chemicals:** Alloxan monohydrate (Sigma-Aldrich Company, St. Louis, Missouri,

USA), Pure cholesterol was obtained from Winlab (UK), cholic acid was obtained from Biomark (India) and methyl thiouracil was purchased from Sigma– Aldrich (USA).

**Kits** of glucose, total cholesterol (T.C), triglyceride (T.G), were purchase from SPINREACT, S.A.U. Ctra. santa Coloma,7E-17176 SANT ESTEVE DE BAS (GI) Spain. Insulin ELISA kits from KAMIYA biochemical company 12779 Gateway Drive, Seattle, WA 98168, USA.

**Animals:** Forty eight adult male Sprague–Dawley rats weighing (245–250 g), at the beginning of the experiment, were obtained from Medical Insects Research Institute, Doki, Cairo, Egypt.

**Standard diet** was prepared from fine ingredients according to AIN-93 guidelines (Reeves et al., 1993).

### **Methods:**

#### **Preparation of red radish roots powder**

The roots were washed to remove soil and dust, and were then rinsed carefully with distilled water and cut to regular

slides. After that, radish roots were dried in Alab Tech oven under vacuum (Model No. Lvo-2040- Korea) at 50°C. It were ground in an electric mill and passed through 80 mesh sieves (British standard screen). The fine powder was kept in glass containers and stored at -20 °C until used.

The chemical composition of dried red radish roots (moisture, crude protein, fat, crude fiber, and ash) were determined as described in the AOAC procedures (2012). Total carbohydrate was estimated by phenol sulfuric according to Sadasivam and Manickam (1997). Total calories were calculated on the basis of a 100g sample using 9, 4 and 4 Kcal for fat, protein and carbohydrate, respectively. Antioxidant activity of dried red radish roots extract was determined by 2, 2 diphenyl-1-picrylhydrazyl (DPPH) according to Yang *et al.*, (2006). Total phenolic compounds were expressed as mg gallic acid equivalents / 100 g dry weight sample. Total flavonoids were determined using a method described by Franke *et al.*, (2004).

Anthocyanin was determined as described by Lako *et al.*, (2007).

#### **Experimental design:**

Rats were housed individually in wire cages under the normal laboratory conditions in Biological Laboratory, Faculty of Home Economics, Menoufia University. Rats were fed on standard diet for one week as an adaptation period. Diet was introduced to rats in special food cups to avoid scattering of food. Also, water was provided to rats by glass tubes projecting through the wire cages from an inverted bottle supported to one side of the cage. Food and fresh water were provided checked daily. Rats were randomly divided into two main groups, the first group, normal control group (n=8) fed standard diet. The rats (n=40) were fasted overnight prior to injection of alloxan dissolved in normal saline at a dose of 150 mg/kg body weight given intraperitoneally (Aruna *et al.*, 1999). Diabetes was identified by visual observations and measuring blood glucose concentration 72h after injection of alloxan. Rats with a fasting

blood glucose level above 200 mg/dl were considered diabetic and were used in this study. Then, all diabetic rats were fed on diet containing with diet composed of cholesterol (1%), cholic acid (0.2%), lard (4%), egg yolk (7%), methyl thiouracil (0.2%), sodium chloride (1%), wheat bran (6.6%), wheat flour (45%) and corn starch (35%) for six weeks according to the method described by **Pengzhan et al., (2003)** to induced Hypercholesterolemia. Total cholesterol (TC) and low density lipoprotein (LDL.c) were determined to assessment of hypercholesterolemia. After divided into four subgroups (8 rats each) as follow: subgroup 1 served as positive control group, subgroup 2, 3 and 4 were fed on the diet containing 2.5%, 5% and 7.5% of dried red radish roots powder for 6 weeks respectively, this dose was guided by previous study **Taniguchi et al., 2006**. After completing the treatment period, animals were sacrificed under diethyl ether anesthesia. Blood samples were collected from the hepatic portal vein, for used to the biochemical assays. Heart

were taken and washed in saline solution until all blood was removed for Aortic histopathological.

#### **Biochemical assays:**

The serum levels triglyceride (TG), total cholesterol (TC). High-density lipoprotein cholesterol (HDL-c), were measured with an automatic analyzer using a diagnostic kit for each according to **Fossati and Prencipe (1982); Allain et al., (1974) and Burstein et al., (1980)** respectively. Glucose was measured in blood and urine according to **Hugget and Nixon (1957)**. The concentration of serum insulin was determined with a Rat insulin ELISA kit. Insulin sensitivity from the final fasting insulin and glucose values was estimated by the Homeostasis model assessment of insulin resistance (HOMA-IR) according to the following formula: [fasting glucose (mM) × fasting insulin (mUI/L)] / 22.5 (**Cordero-Herrera et al., 2015**). Low Density Lipoprotein (LDL.c) was calculated from friedewald formula  $LDL,c = TC - HDL.c - TG/5.0$  (mg/dL)

(Friedewald *et al.*, 1972). The Atherogenic ratios were calculated as follows: Atherogenic Index of Plasma (AIP) =  $\log \text{ TG/HDLc}$ , Cardiac risk ratio (CRR), =  $\text{TC/HDLc}$  Castelli's Risk Index (CRI) =  $\text{LDLc/HDLc}$ , Atherogenic Coefficient (AC) =  $(\text{TC} - \text{HDLc}) / \text{HDLc}$  according to **Bhardwaj *et al.*, (2013)** and Atherogenic fraction (AF) was calculated as the difference between TC and HDL-C according to **Aguilar *et al.*, (2011)**.

#### ***Analyses of hepatic lipid profile***

The content of hepatic total lipids, triglyceride and total cholesterol were analyzed as described previously **Bligh and Dyer (1959)** ; **Hossain *et al.*, (2011)** and **Shahdat *et al.*, (2004)** respectively.

#### ***Histopathological Staining of Aorta***

Aortic tissues were fixed in 10% (v/v) formalin in 0.01M phosphate buffered saline (PBS) for 2 days with change of formalin solution every day to remove traces of blood from tissue. The tissue samples were dehydrated and embedded in

paraffin, and then thin sections (6 $\mu$ m) of the aortic arch in each group were cut and stained with hematoxylin eosin according to **kho *et al.*, (2014)**.

#### ***Statistical analysis:***

Results were expressed as the mean  $\pm$  SD. Data for multiple variable comparisons were analyzed by one-way analysis of variance (ANOVA). For the comparison of significance between groups, Duncan's test was used as a post hoc test according to the statistical package program (**Armitage and Berry, 1987**).

## **RESULTS & DISCUSSION**

Data in Table (1) showed total phenolic compounds, total flavonoids, anthocyanin, antioxidant activity and proximate chemical composition of dried red radish roots. Total phenolic, total flavonoids, anthocyanin and antioxidant activity of dried red radish roots were 11.68 mg gallic/100 g, 18.52 mg catechin/100 g, 29.69 mg cyaniding -3- glucoside/100 g and 82.15% respectively. **Goyeneche *et al.*, (2015)**

reported that total phenolic, total flavonoids and antioxidant activity of red radish roots were 341.45 mg gallic acid equivalent (GAE) /100 g dry matter (d.m.), 267.47 mg quercetin /100 g d.m. and 1.36 mmol trolox equivalent (TE)/100g d.m. respectively. The red radish is characterized by a high flavonoid content including quercetin and kaempferol, high levels of anthocyanin and phenolic compounds reported by **Hanlon and Barnes (2011)**. A radish roots extract had in vitro antioxidant activity (**Lugsai et al., 2005**).

Also, in Table (1) the dried red radish roots had 16.49 g /100g moisture, 0.62 g/100g total fat, 6.67 g/100g crude protein, 48.56 g /100g carbohydrate, 21.06 g/100g fiber and 6.60 g /100g total ash. Energy content was 226.5 Kcal. **Goyeneche et al., (2015)** found that dried red radish roots contain moisture (16 g/100g), crude protein (10.06 g/100 g), lipid content (1.24 g/100g), ash (13.59g/100 g), crude fiber (5.65 g/100g) and carbohydrates (53.47 g /100g). **Levine et al., (2008)** reported that high

concentration of complex carbohydrates and dietary fiber in radish roots is one of the nutritional benefits.

Effect of dried red radish roots on glucose in blood and urine and insulin in normal and hypercholesterolemic diabetic rats are represented in Table (2). The data indicated that hypercholesterolemic diabetic rats had significantly ( $P \leq 0.05$ ) high blood glucose level as compared with normal rats. At the final day of the experimental period, blood glucose level still high in the untreated hypercholesterolemic diabetic rats but in hypercholesterolemic diabetic rats treated with 2.5, 5 and 7.5% of dried red radish roots blood glucose level were decreased by 24.2, 37.29 and 50.15% respectively compared to the initial day. The highest reduction in blood glucose level was noted in hypercholesterolemic diabetic rats treated with 7.5% of dried red radish roots. These results were in agree with **Aly et al., (2015)** who showed that Egyptian radish had a hypoglycemic effect in diabetic

status. *Raphanus sativus* roots juice possesses good hypoglycemic potential coupled with antidiabetic efficacy (Shukla *et al.*, 2011). The hypoglycemic effect of red radish roots may be due to its content of flavonoids and anthocyanins. Vinayagam and Xu (2015) suggest that anthocyanins had antidiabetic activities. Also, the consumption of flavonoids or flavonoids - rich foods may reduce the risk of diabetes reported by Bahdoran *et al.*, (2013). On the other hand, glucose was not detected in the urine of normal rats, while hypercholesterolemic diabetic untreated rats (0% red radish roots) were highly glycosuric. At the final day of the experiment, the treatment with 2.5, 5 and 7.5% of dried red radish roots resulted in a significant ( $P \leq 0.05$ ) reduce in urine glucose level by 29.31, 50.46 and 69.95% respectively in comparison with the initial day. Moreover, dried red radish roots at concentration 7.5% was identified as the most effective in lowering urine glucose level. Shin *et al.*, (2015) suggested that radish contains a variety of antioxidant

constituents, which may play important roles in body homeostasis in vivo.

The results in the same table illustrated that there were significant decrease ( $P \leq 0.05$ ) in serum insulin level in hypercholesterolemic diabetic rats as compared to normal rats. On the other hand, a significant increase ( $p \leq 0.05$ ) in serum insulin level was observed in hypercholesterolemic diabetic rats treated with 2.5, 5 and 7.5% of dried red radish roots in the final day of experiment period, whereas serum insulin level was increased by 47.06, 117.78 and 138.46% respectively for the first day of experiment. Furthermore hypercholesterolemic diabetic rats treated with 5 and 7.5% dried red radish roots had the highest insulin sensitivity index value than rats treated with 2.5% ( $P \leq 0.05$ ). These obtained results were in accordance with results of Aly *et al.*, (2015) and Amer *et al.*, (2004) who reported that antioxidants, such as flavonoids and phenols in Egyptian and Japanese radish improved insulin sensitivity and thereby

induced the hypoglycemic effect.

Table (3) shows the effect of dried red radish roots on serum lipid profile in normal and hypercholesterolemic diabetic rats. The results indicated that the levels of serum total cholesterol (T.C), triglyceride (T.G), LDL-c and VLDL-c were significantly increased ( $P \leq 0.05$ ) in hypercholesterolemic diabetic rats as compared to those of the normal control rats, while HDL-c had an opposite trend. These result agree with those obtained by **Aly *et al.* (2015)** and **Haque *et al.*, (2014)** who found that the levels of serum and plasma lipid profile (TC, TG, LDL-c and VLDL-c) increased in hypercholesterolemic diabetic rats. Any changes in the levels of lipids make the individuals more inclined to develop atherosclerotic cardiovascular diseases as well as endothelial dysfunction (**Parinita, 2012**). The abnormal high concentration of serum lipids in diabetic rats are due mainly to an increase in the mobilization of free fatty acids from the

peripheral fat depots, since insulin inhibits the hormone - sensitive lipase departed by **Pushparaj *et al.*, (2000)**. The levels of TC, TG, LDL-c and VLDL-c in serum significantly ( $P \leq 0.05$ ) decreased in hypercholesterolemic diabetic rats treated with different concentrations of red radish roots compared with untreated rats (0% red radish roots group), while no significant ( $P > 0.05$ ) differences were observed in TC and LDL-c between hypercholesterolemic diabetic rats treated with 2.5% and 5% of red radish roots (Table 3). Also, the treatment of 7.5% red radish roots was more effective ( $p \leq 0.05$ ) in reducing the levels of TC, TG, LDL-c and VLDL-c and increasing HDL-c compared to other concentrations. These effects may be due to *Raphanus sativus* increases the lipid metabolism and lowers the lipid plasma by increasing the activity of lipoprotein lipase reported by **Yoshida *et al.*, (2005)**. These results agree with those obtained by **Haque *et al.*, (2014)** who found that the levels of plasma T.C, T.G and LDL-c significantly reduced in

hypercholesterolemic rats treated with hot water radish extract. Also, fresh red radish roots juice decreased serum T.C, T.G, LDL-c and VLDL-c and elevated the level of HDL-c in rats reported by **Sadeek (2011)**. The improvement of serum lipid profile in rats treated with different concentrations of dried red radish roots may be related to its content of flavonoid, whereas higher dietary flavonoid intake was associated with improving lipid profile (**Li et al., 2013**). However, **Taniguchi et al., (2006)** reported that no significant changes were observed in the lipid profiles in diabetic rats fed 0%, 2.5% and 5% of Japanese radish (JRS), although JRS decrease T.G. Because a risky relationship between serum lipids and cardiovascular disease has been reported by **He et al., (2004)**, lowering serum cholesterol and triglyceride levels is important for the prevention of high - mortality lifestyle - related cardiovascular disease.

The results of Table (4) show effect of dried red radish roots on atherogenic indices and

LDL-c/HDL-c Ratio (HTR%) in normal and hypercholesterolemic diabetic rats. A significant increase ( $P \leq 0.05$ ) in Atherogenic Index (AI), cardiac risk ratio (CRR%), castelli's Risk Index (CRI), Atherogenic fraction (AF) and Atherogenic coefficient (AC) were observed in hypercholesterolemic diabetic rats compared to normal rats. However, HTR% of hypercholesterolemic diabetic rats were lower ( $P \leq 0.05$ ) than normal rats. These results could be attributed high serum levels of TC, TG, LDL-c and VLDL-c as well as lower levels of HDL.c which was observed in hypercholesterolemic diabetic rats. The present results were in accordance with those of **Adaramoye and Akanni (2014)** who showed that hypercholesterolemic rats had high serum, hepatic and cardiac TC, TG and LDL-c. Diabetes is associated with abnormalities of lipid metabolism and an increase in the atherogenic index (**Tripathi, 2003**). Atherogenic indices are powerful indicators of the risk of cardiovascular diseases, the higher the

atherogenic indices value, the higher the risk for developing cardiovascular diseases reported by **chigozie and chidinma (2013)**. On the other hand, Atherogenic index (AI) was significantly reduced ( $P \leq 0.05$ ) in hypercholesterolemic diabetic rats treated with 2.5, 5 and 7.5% of dried red radish roots compared with hypercholesterolemia diabetic rats untreated (0% red radish roots), while HTR% had an opposite trend. However, treatments with 5 and 7.5% of dried red radish roots had significantly decreased ( $P \leq 0.05$ ) in CRR%, CRI, AF and AC in hypercholesterolemic diabetic rats in comparison to hypercholesterolemic diabetic rats untreated (0% red radish roots). Moreover, the highest reduction ( $P \leq 0.05$ ) in AI, CRR%, CRI, AF and AC and the highest elevation ( $P \leq 0.05$ ) in HTR% were observed in hypercholesterolemic diabetic rats treated with 7.5% of dried red radish roots compared to other concentrations. These finding agree with those reported by **Haque et al., (2014)** who found that the atherogenic index

reduced by 24% in the hypercholesterolemic rats treated with *Raphanus sativus* extract, as noted the atherogenic indices were reduced significantly in the hypercholesterolemic rats as a result of oral administration of *Raphanus sativus* extract. Low atherogenic indices are protective against coronary heart disease (**Chigozie and Chidinma, 2013**). Thus radish roots had good protective effects against cardiovascular complications.

Data recorded in Table (5) showed effect of dried red radish roots on hepatic lipid parameters in normal and hypercholesterolemic diabetic rats. The results revealed that hypercholesterolemic diabetic rats had significantly ( $P \leq 0.05$ ) high total lipids (T.L), triglyceride (T.G) and total cholesterol (T.C) levels comparing to normal rats. This was in agreement with the results of **Haque et al., (2014)** and **Mariee et al., (2012)** who reported that hypercholesterolemic rats showed a marked elevated in the levels of hepatic T.C and T.G.

Elevated liver TG was caused by increasing the rate of hepatic lipogenesis, concomitantly with the ability of ROS to block its secretion into the plasma (**Ferreira Ede et al., 2011**). Furthermore, **Halim et al., (1997)** indicated that high contents of liver cholesterol are due to disturbed catabolism of cholesterol into bile acids. In contrast of these results **Taniguchi et al., (2006)** observed that hepatic T.G level reduced in diabetic rats.

From Table (5) it was obvious that there was a significant decrease ( $P \leq 0.05$ ) in hepatic T.L and T.G in hypercholesterolemic diabetic rats treated with 2.5%, 5% and 7.5% of red radish roots as compared to untreated rats (0% red radish roots), however hepatic T.C was significantly ( $p \leq 0.05$ ) decreased in hypercholesterolemic diabetic rats treated with 5 and 7.5% of dried red radish roots compared with untreated rats. The highest significant reduction in hepatic T.L, T.G and T.C levels was observed in hypercholesterolemic diabetic

rats treated with 7.5% of red radish roots. The hot water radish extract reduced the hepatic T.C and T.G levels in hypercholesterolemic rats, the hypercholesterolemic of radish might be related to the ingestion of saponin - rich foods such as Radish might had increased fecal excretion of cholesterol led to decreased hepatic cholesterol (**Haque et al., 2014 and Zhao et al., 2008**). The obtained results were in accordance with results of **Castro - Torres et al., (2014)** who found that black radish juice reduces hepatic cholesterol level. Also, **Rahman et al., (2013)** reported that the extract of *Raphanus sativus* Linn (Radish) significantly decreases the serum and liver cholesterol.

Figure (1) showed the histopathological changes of aorta tissue in normal and hypercholesterolemic diabetic rats. From the histopathological examination of the rat aorta section under study, the section of the aorta of normal rats showed no histopathological changes (normal tunica media) (H & E X 400) (fig.1A). Hypercholesterolemic diabetic

rats untreated (0% red radish roots) showed vacuolation of the smooth muscles of tunica media of aorta (H & E X 400) (fig.1B). Smooth muscle degeneration together with cell proliferation in aorta was observed in diabetic rats (**Karasu et al., 1997**). Hypercholesterolemic rats had aorta with disorder arrangement unclear borderlines and partial deletion as well as increased foam cell formation and tunica media thickness of the vascular walls reported by **Deng et al., (2015)**.

However, hypercholesterolemic diabetic rats treated with 2.5, 5 and 7.5 % of dried red radish roots, their aorta sections appeared normal (H & E X 400) (fig.1C, D and E respectively). **Haque et al., (2014)** who found that *Raphanus sativus* extract possess protective effects against cardiovascular complications. Crude radish extract (*Raphanus sativus*, Korean white radish) inhibits cell proliferation in mouse aortic smooth muscle cells (**Suh et al., 2006**), suggesting that radish isothiocyanates may protect against abnormal cell proliferation in vascular smooth muscle cells.

In conclusion, all of the results indicate a possible protective mechanism of the dried red radish roots against the development of atherosclerosis and coronary heart disease as well as the dyslipidemic conditions that characterize diabetes mellitus. Results showed that dried red radish roots which are a rich source of flavonoids and anthocyanins have hypoglycemic effects and can improve the levels of insulin and lipid metabolism in rats. Therefore, red radish roots in everyday diet would be beneficial.

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**Table (1): Total phenolic, total flavonoids, anthocyanin , antioxidant activity and proximate chemical composition of dried red radish roots.**

Parameters	Dried red radish root
Total phenolic compounds (mg gallic acid/100 g)	11.68 ± 3.95
Total Flavonoids (mg catechin/100 g)	18.52 ± 0.47
Anthocyanin (mg cyanidin-3-glucoside/100 g)	29.69 ± 1.63
Antioxidant activity (%)	82.15 ± 1.67
Caloric values (Kcal)	226.5 ± 9.94
Moisture (g/100 g)	16.49 ± 1.61
Total fat (g/100 g)	0.62 ± 0.16
Crude protein (g/100 g)	6.67 ± 1.08
Carbohydrate (g/100 g)	48.56 ± 2.47
Fiber (g/100 g)	21.06 ± 3.17
Total ash (g/100 g)	6.60 ± 2.06

Each value in the table is the mean ± standard deviation of three replicates.

**Table (2): Effect of dried red radish roots on glucose in blood and urine and insulin in normal and hypercholesterolemic diabetic rats**

Parameters	Normal rats	Hypercholesterolemic diabetic rats			
		0% red radish roots	2.5% red radish roots	5% red radish roots	7.5% red radish roots
<b>Glucose in blood mg/dl</b>					
<b>First day</b>	99.39 <sup>Ab</sup> ± 0.69	310.73 <sup>Ba</sup> ± 1.18	310.18 <sup>Aa</sup> ± 1.49	310.52 <sup>Aa</sup> ± 1.71	309.90 <sup>Aa</sup> ± 1.06
<b>Final day</b>	98.32 <sup>Ac</sup> ± 1.37	320.17 <sup>Aa</sup> ± 1.11	235.15 <sup>Bb</sup> ± 0.86	194.73 <sup>Bc</sup> ± 2.20	154.47 <sup>Bd</sup> ± 1.08
<b>% lowering of blood glucose level</b>	1.08	-	24.2	37.29	50.15
<b>Glucose in urine mmol/L</b>					
<b>First day</b>	0.0	57.95 <sup>Ba</sup> ± 1.46	57.21 <sup>Aa</sup> ± 0.93	57.09 <sup>Aa</sup> ± 1.21	58.43 <sup>Aa</sup> ± 0.95
<b>Final day</b>	0.0	68.32 <sup>Aa</sup> ± 1.31	40.44 <sup>Bb</sup> ± 0.91	28.28 <sup>Bc</sup> ± 1.44	17.56 <sup>Bd</sup> ± 0.59
<b>% lowering of urine glucose level</b>	0.0	-	29.31	50.46	69.95
<b>Insulin in serum (ng/mg)</b>					
<b>First day</b>	2.51 <sup>Aa</sup> ± 0.10	0.49 <sup>Ab</sup> ± 0.35	0.51 <sup>Bb</sup> ± 0.03	0.45 <sup>Bb</sup> ± 0.04	0.52 <sup>Bb</sup> ± 0.05
<b>Final day</b>	2.54 <sup>Aa</sup> ± 0.13	0.49 <sup>Ac</sup> ± 0.04	0.75 <sup>Ad</sup> ± 0.01	0.98 <sup>Ac</sup> ± 0.01	1.24 <sup>Ab</sup> ± 0.09
<b>% change of Insulin in serum</b>	0.0	0.0	47.06	117.78	138.46
<b>Insulin sensitivity index (HOMA-IR)</b>	25.75 <sup>a</sup> ± 1.47	16.20 <sup>d</sup> ± 1.17	18.14 <sup>c</sup> ± 0.35	19.68 <sup>b</sup> ± 0.35	19.66 <sup>b</sup> ± 1.31

Data are expressed as mean ± SD. Values within a row having different superscripts are significantly different ( $p \leq 0.05$ ); where the small letters indicate significant among dietary treatment groups as indicated by one-way ANOVA followed by Duncan's

multiple range test ( $a > b > c > d > e$ ), while capital letters referred to statistical differences among experimental periods, HOMA-IR:

**Table (3): Effect of dried red radish roots on serum lipid profile in normal and hypercholesterolemic diabetic rats**

Parameters	Normal rats	Hypercholesterolemic diabetic rats			
		0% red radish roots	2.5% red radish roots	5% red radish roots	7.5% red radish roots
<b>T.C(mg/dl)</b>	98.08 <sup>d</sup> ± 1.12	208.70 <sup>a</sup> ± 2.97	207.39 <sup>a</sup> ± 4.1	177.10 <sup>b</sup> ± 2.19	158.11 <sup>c</sup> ± 5.07
<b>T.G (mg/dl)</b>	85.41 <sup>e</sup> ± 1.04	166.48 <sup>a</sup> ± 2.50	160.29 <sup>b</sup> ± 3.26	132.15 <sup>c</sup> ± 2.76	114.22 <sup>d</sup> ± 2.08
<b>HDL.c (mg/dl)</b>	57.24 <sup>a</sup> ± 1.05	24.80 <sup>d</sup> ± 2.26	26.16 <sup>d</sup> ± 1.83	38.17 <sup>c</sup> ± 2.09	46.67 <sup>b</sup> ± 2.22
<b>LDL.c (mg/dl)</b>	23.76 <sup>d</sup> ± 1.91	150.61 <sup>a</sup> ± 4.60	149.17 <sup>a</sup> ± 3.57	112.50 <sup>b</sup> ± 3.69	88.60 <sup>c</sup> ± 4.22
<b>VLDL.c (mg/dl)</b>	17.08 <sup>e</sup> ± 0.21	33.29 <sup>a</sup> ± 0.50	32.06 <sup>b</sup> ± 0.65	26.43 <sup>c</sup> ± 0.55	22.84 <sup>d</sup> ± 0.42

Data are expressed as mean ± SD. Values within a row having different superscripts are significantly different ( $p \leq 0.05$ ); where the small letters indicate significant among dietary treatment groups as indicated by one-way ANOVA followed by Duncan's multiple range test ( $a > b > c > d > e$ )

**Table (4): Effect of dried red radish roots on atherogenic indices and LDL/HDL Ratio (HTR %) in normal and hypercholesterolemic diabetic rats .**

Parameters	Normal rats	Hypercholesterolemic diabetic rats			
		0% red radish roots	2.5% red radish roots	5% red radish roots	7.5% red radish roots
<b>AI (mg/dl)</b>	0.17 <sup>c</sup> ± 0.01	0.83 <sup>a</sup> ± 0.40	0.79 <sup>b</sup> ± 0.03	0.54 <sup>c</sup> ± 0.03	0.39 <sup>d</sup> ± 0.02
<b>CRR</b>	1.71 <sup>d</sup> ± 0.04	8.42 <sup>a</sup> ± 0.87	7.93 <sup>a</sup> ± 0.52	4.64 <sup>b</sup> ± 0.29	3.39 <sup>c</sup> ± 0.13
<b>CRI (mg/dl)</b>	0.42 <sup>d</sup> ± 0.04	6.07 <sup>a</sup> ± 0.74	5.70 <sup>a</sup> ± 0.44	2.95 <sup>b</sup> ± 0.44	1.90 <sup>c</sup> ± 0.12
<b>AF (mg/dl)</b>	40.84 <sup>d</sup> ± 1.89	183.9 <sup>a</sup> ± 4.69	181.23 <sup>a</sup> ± 3.64	138.93 <sup>b</sup> ± 3.72	111.44 <sup>c</sup> ± 4.37
<b>AC (mg/dl)</b>	0.72 <sup>d</sup> ± 0.04	7.48 <sup>a</sup> ± 0.87	6.96 <sup>a</sup> ± 0.52	3.65 <sup>b</sup> ± 0.29	2.39 <sup>c</sup> ± 0.13
<b>HTR%</b>	0.58 <sup>a</sup> ± 0.06	0.12 <sup>d</sup> ± 0.02	0.13 <sup>d</sup> ± 0.01	0.22 <sup>c</sup> ± 0.01	0.30 <sup>b</sup> ± 0.01

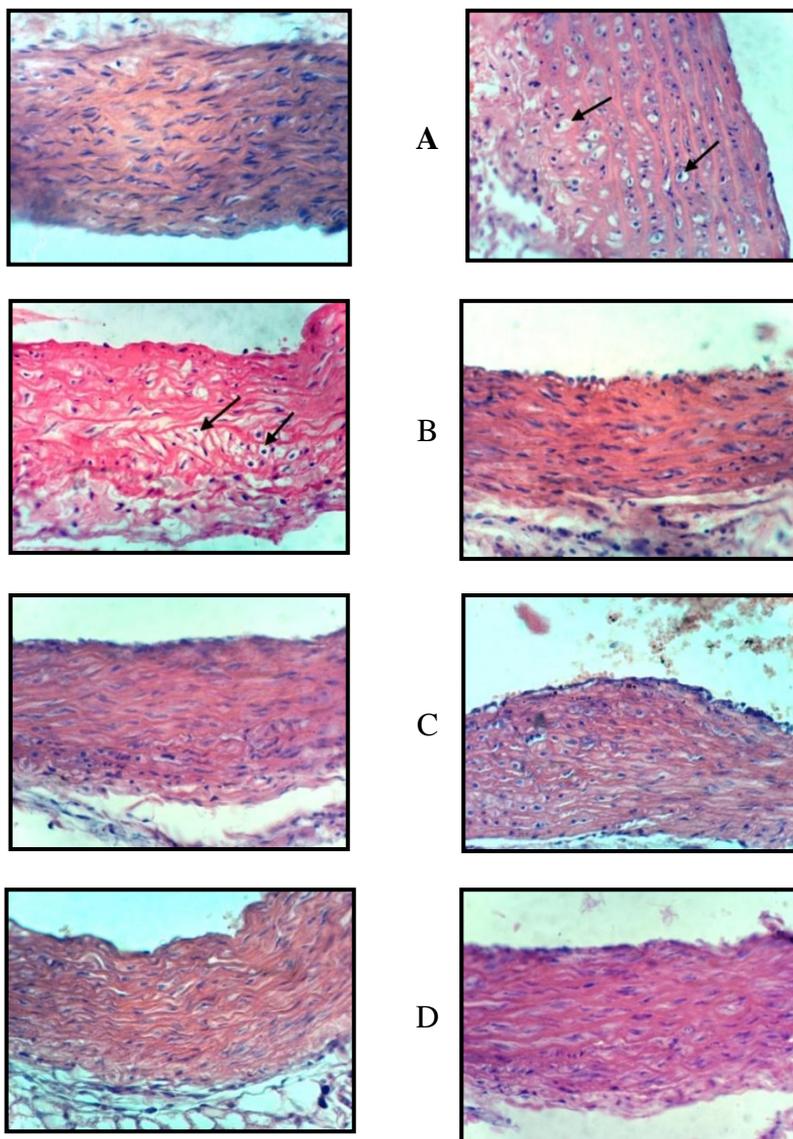
Data are expressed as mean ± SD. Values within a row having different superscripts are significantly different ( $p \leq 0.05$ ); where the small letters indicate significant among dietary treatment groups as indicated by one-way ANOVA followed by Duncan's multiple range test ( $a > b > c > d > e$ ). Atherogenic Index (AI) =  $\log \text{ TG/HDLc}$ , Cardiac risk ratio (CRR) =  $\text{TC/HDLc}$ , Castelli's Risk Index (CRI) =  $\text{LDLc/HDLc}$  Atherogenic Coefficient (AC) =  $(\text{TC} - \text{HDLc})/\text{HDLc}$ , Atherogenic fraction (AF) was calculated as the difference between TC and HDL-C, HTR =  $\text{HDL/TC}$  Ratio.

**Table (5): Effect of dried red radish roots on hepatic lipid parameters in normal and hypercholesterolemic diabetic rats**

Parameters	Normal rats	Hypercholesterolemic diabetic rats			
		0% red radish roots	2.5% red radish roots	5% red radish roots	7.5% red radish roots
<b>T.L (Mmol/g tit)</b>	1.79 <sup>e</sup> ± 0.06	3.87 <sup>a</sup> ± 0.28	3.09 <sup>b</sup> ± 0.08	2.56 <sup>c</sup> ± 0.08	2.19 <sup>d</sup> ± 0.18
<b>T.G (Mmol/g tit)</b>	0.73 <sup>e</sup> ± 0.05	1.95 <sup>a</sup> ± 0.03	1.39 <sup>b</sup> ± 0.05	1.11 <sup>c</sup> ± 0.04	0.95 <sup>d</sup> ± 0.03
<b>T.C (Mmol/g tit)</b>	91.38 <sup>d</sup> ± 1.02	224.27 <sup>a</sup> ± 3.65	221.96 <sup>a</sup> ± 2.59	154.91 <sup>b</sup> ± 3.88	138.87 <sup>c</sup> ± 3.05

Data are expressed as mean ± SD. Values within a row having different superscripts are significantly different ( $p \leq 0.05$ ); where the small letters indicate significant among dietary treatment groups as indicated by one-way ANOVA followed by Duncan's multiple range test ( $a > b > c > d > e$ ).

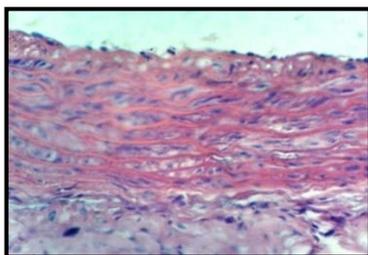
**Fig.(1): Histopathological changes of aorta tissue in normal and hypercholesterolemic diabetic rats.**



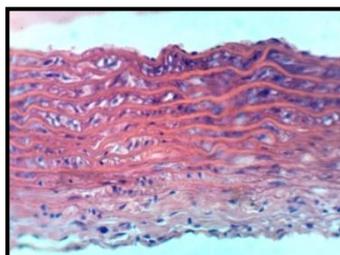
*Antidiabetic and Antiatherosclerotic activity of dried red radish roots (Raphanus sativus L) on hypercholesterolemic diabetic rats*

*Abeer A. Khedr – Naglaa A. El Sheikh*

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A: normal control, B: Hypercholesterolemic diabetic rats untreated (0% red radish roots), C: Hypercholesterolemic diabetic rats treated with 2.5% red radish roots, D: Hypercholesterolemic diabetic rats treated with 5% red radish roots, E: Hypercholesterolemic diabetic rats treated with 7.5% red radish roots.

## النشاط المضاد للسكري وتصلب الشرايين لجذور الفجل الأحمر الجافة في الجرذان المصابة بالسكري وارتفاع كوليسترول الدم

عبير أحمد خضر و نجلاء على مجد الشيخ

قسم التغذية وعلوم الأطعمة بكلية الاقتصاد المنزلي جامعة المنوفية ، شبين الكوم، مصر

### الملخص العربي

هذه الدراسة اجريت لتقييم التأثير الخافض لسكر الدم و المضاد لتصلب الشرايين لجذور الفجل الاحمر الجافة على الجرذان المصابة بالسكري و ارتفاع كوليسترول الدم . تحتوى جذور الفجل الاحمر على كميات جيدة من المركبات الفعالة مثل المركبات الفينولية و الفلافونويدات و الأنثوسيانين كمضادات أكسدة ،قسمت الجرذان عشوائيا إلى مجموعتين رئيسيتين ، المجموعة الأولى الضابطة السالبة، و المجموعة الثانية هى الجرذان المصابة بالسكر و ارتفاع كوليسترول الدم وقسمت هذه المجموعة إلى أربع مجموعات فرعية ( ٨ فئران بكل منها) على النحو التالى : المجموعة الأولى الضابطة الموجبة ، المجموعة الثانية والثالثة والرابعة تغذت على وجبة تشتمل على ٢,٥ ، ٥ ، ٧,٥ ٪ من مسحوق جذور الفجل الأحمر الجافة لمدة ٦ أسابيع على التوالي. بعد اكتمال فترة المعاملة، تم تجميع عينات الدم لإجراء التحاليل البيوكيميائية مثل سكر الدم و الانسولين و صورة دهون الدم ، وتم اخذ القلب لإجراء الفحص النسيجي للأورطى . وقد أشارت النتائج إلى أن المعاملة بجذور الفجل الأحمر الجافة أدت إلى انخفاض معنوى في مستويات كلا من جلوكوز الدم والبول ، مستوى الدهون ، دهون الكبد ومؤشرات التجلط مقارنة بالمجموعة الضابطة الموجبة مع تحسن في مستوى الإنسولين والتغيرات الهستوباثولوجية في الأورطى في الجرذان المصابة بالسكري وارتفاع كوليسترول الدم. وقد خلصت الدراسة إلى أن جذور الفجل الأحمر كمصدر للمركبات المضادة للأكسدة لديها تأثير مخفض للسكر وتحسين ميثابوليزم الدهون مع الوقاية من أمراض الأوعية الدموية.

**الكلمات الكشافة :** جذور الفجل الأحمر- مؤشرات التجلط - النشاط المضاد للسكري -

الجرذان المصابة بالسكري وارتفاع كوليسترول الدم.