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The effect of dried figs (*Ficus carica L.*) on hypercholesterolemia in rats

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Abstract--This study aimed to evaluate the effect of dried figs with high content of antioxidants namely fig (*Ficus carica L.*) on lowering blood cholesterol in hypercholesterolemic rats. Vitamins A and C, total polyphenols and total flavonoids were determined in figs in fresh fruits and after being dried. All these antioxidants were found in considerable amounts in fig. Thirty male albino rats were divided into six groups 5each, the first group received a standard and served as a negative control, and the second group received a hypercholesterolemic diet and served as a positive control. Group 4 was the protective group that fed on a higher percentage of figs 6% and the other three groups received a hypercholesterolemic diet containing different levels from fig (2, 4 and 6%) for 8 weeks. At the end of this period, blood was withdrawn after overnight fasting and biochemical parameters were analyzed. Serum total cholesterol, serum triacylglycerol (TG), serum low density lipoprotein cholesterol (LDL-C), serum very low density lipoprotein cholesterol (VLDL-C), serum high density lipoprotein cholesterol (HDL-C) and atherogenic index (LDL-C/HDL-C) were estimated. Also, the activity of the liver enzymes ALT and AST were determined. A histopathological examination of the aorta was done. Results revealed that the positive control group showed a significant increase in TC, TG, LDL-C, VLDL-C and atherogenic index (LDL-C/HDL-C), while there was a significant decrease in the concentration of serum HDL-C. Also, there was a significant increase in activities of ALT and AST for the positive control group as compared to the negative control group. The histopathological examination of the aorta from the positive control

group revealed abnormal alterations. All these alterations in biochemical parameters and histopathological examination were more or less normalized in the groups that were fed a hypercholesterolemic diet supplemented with different levels of dried fig compared to the negative control group. Depending on these results, it can be concluded that supplementing a hypercholesterolemic diet with dried figs can exert a hypocholesterolemic effect in rats which was attributed to the potent antioxidant power of these fruits. Consequently, consuming large quantities of this fruit is believed to lower the serum cholesterol levels thus protecting against cardiovascular diseases. Moreover, it can be used in those patients with atherosclerosis as adjuvant therapy.

Keywords---Hypercholesterolemia, lipids profile, cholesterol, rats, dried figs, antioxidant, polyphenols, flavonoids.

Introduction

Cardiovascular disease (CVD) is a leading cause of mortality, morbidity, and reduced quality of life in Europe, including the UK, and is associated with a significant clinical and economic burden. It is the cause of about 4 million deaths every year in Europe, accounting for 45% of all deaths, and including more than 160,000 deaths each year in the UK, accounting for 27% of all deaths and equivalent to one death every three minutes. With more patients surviving their first cardiovascular (CV) event, CVD is also a major cause of disability, reduced quality of life, and poor clinical outcomes Mach *et al.*, (2019). About 85 million people in Europe, including approximately 7.6 million people in the UK, are living with CVD; in the UK, this represents twice as many people living with cancer and Alzheimer's disease combined British Heart Foundation (2021).

Hypercholesterolemia is a problem faced by many societies and is a cause of concern for health professionals, since it constitutes one of the major risk factors for the development of cardiovascular diseases, such as atherosclerosis and its complications, acute infarction of the myocardium or hypertension (Gomes *et al.*, 1998; Gerhardt and Gallo 1998). In addition, there is a close correlation between these diseases and lipid abnormalities, especially high level of plasma cholesterol, and blood pressure Mahan and Scott-Stump (1998).

Mediterranean and dietary approaches to stop hypertension (DASH) dietary interventions are well studied for CVD outcomes. Both dietary patterns may reduce the incidence of CVD through the down-regulation of low-grade inflammation and better control of body weight, which also improve other risk factors, and are correlated with lower numbers of clinical events Silveira *et al.*, (2018).

Fruits are truly among nature's great gifts because they provide many nutrients that are essential for the health and maintenance of our bodies. They are commonly consumed fresh, but can also be eaten in a dried state. Almost all dried fruits provide essential nutrients and an array of health protective bioactive

ingredients that help to reduce the risk of illness by preventing chronic diseases. Natural products have the potential to be used as therapeutic drugs for humans and livestock species. Such compounds, along with their analogs, can also act as intermediates to produce useful drugs Makkar, *et al.*, (2009).

Ficus is one of the largest genera of angiosperms from the mulberry family with more than 800 species of trees, shrubs, hemi epiphytes, climbers and creepers in the tropical and subtropical region all over the world. The most significant species of *Ficus* found in India, are *F. bengalensis*, *F. carica*, *F. racemosa* and *F. elastica*. *Ficus carica* belongs to the Moraceae family and is commonly known as "Fig" (Anjir in hindi) in India. Different plant parts like fruits, seeds, leaves, tender, bark, shoots and latex have numerous medicinal applications. Major producers of figs are Turkey, Egypt, Morocco, Spain, Greece, California, Italy, Brazil, and other countries with hot dry summers and mild winters (Joseph and Rej, 2011). So figs are an important harvest throughout the world and are consumed both in dried and in a fresh state. Figs are generally marketed after drying because fresh fig fruit is available only during the season so dried figs fruit is commonly found in the market. Juice from fig fruit when mixed with honey can be used for haemorrhages.

Figs can also be used as a mild laxative, an expectorant and a diuretic. The dried figs are used as a feed supplement by diabetics and because of the high amount of sugars in them; it is consumed as a sweet. Dried figs are reported to be a good source of carbohydrates, sugars, minerals, vitamins, organic acids and phenolic compounds Slatnar *et al.*, (2011). Both fresh and dried figs have high amounts of fiber and polyphenols Vinson *et al.*, (2005). Figs are found to be a rich source of amino acids.

They are also free of fat and cholesterol. As per USDA data for the Mission variety of figs, dried figs are an excellent source of fiber, Vitamin K and minerals like copper, manganese, magnesium, potassium, and calcium relative to human needs Guarrera *et al.*, (2005). The phytochemical content of *F. carica* shows that it is a potent source of flavonoids and polyphenols and various other compounds like arabinose, β -amyrins, β - carotines, glycosides, β -setosterols and xanthotoxol. Alkaloids, flavonoids, coumarins, saponins and terpenes have also been reported in aqueous extract of the ripe dried fruit of *Ficus carica* Gilani (2008). Therefore, this study was conducted to evaluate the effect of dried figs on Hypercholesterolemic rats.

Materials and Methods

Materials

Casein, cellulose, vitamins, choline bitartrate and L-cysteine were obtained from the Global Company for Chemicals Trading, Cairo, Egypt. Minerals and formalin were purchased from El-Gomhoria Company, Cairo, Egypt. Cholesterol powder was purchased from El-Gomhoria Pharmaceutical Company, Cairo, Egypt. Kits for blood analysis were purchased from Gama Trade Company for Chemicals, Cairo, Egypt. Rats were purchased from Experimental Animals' Station,

Agricultural Research Center, Giza, Egypt. Fig (*Ficus carica L.*), was obtained from Agriculture Research Center, Giza, Egypt.

Methods

Fig Drying

Fig was dried using the solar energy at 40°C for two days and then ground to get fine powder at Solar Energy Station, Agriculture Research Center, Giza, Egypt.

Determination of Total phenolic content (TPC)

Total phenolic content was determined using Folin Ciocalteu reagent McDonald *et al.*, (2001). An aliquot (100µl) of extract was mixed with 250 µl of Folin Ciocalteu's reagent and allowed to stand at room temperature for 5 min. 1.5 ml of 20% sodium bicarbonate was added to this mixture and incubated at room temperature for 2 h. Absorbance was measured at 765nm using a spectrophotometer. The results were expressed in terms of µg Gallic acid equivalents (GAE)/mg of dry extract.

Determination of Total flavonoids content

Total flavonoids content was measured by using aluminium chloride colorimetric method Chang *et al.*, (2002) and expressed in terms of mg catechin equivalents (CE)/g of dry extract. Total flavonoids were determined using Catechin as standard. The sample extract (250 µl) was added to 4.5 ml distilled water, followed by 5% NaNO₂ (0.03 ml). After 5 min at 25 °C, AlCl₃ (0.03 ml, 10%) was added. After another 5 min, the reaction mixture was treated with 2 ml of 1M NaOH. Finally the reaction mixture was diluted to 10 ml with distilled water and absorbance was measured at 510 nm. The results were expressed as catechin equivalents (CE) in µg/ mg of dried extract.

Induction of Hypercholesterolemia

Hypercholesterolemia was induced by adding 1% cholesterol powder with 0.5% bile salt to the basal diet for 2 weeks Takako *et al.*, (2006).

Diet Composition and Experimental Animal Design

The basal diet was formulated according to the AIN-93M diet (Reeves *et al.*, 1993). After the acclimatization period (7days), 30 rats were divided into six groups (5each), the first group was fed a basal diet and served as a negative control, and the second group was fed a hypercholesterolemic diet and served as a positive control. Group 3 was the protective group that was fed a basal diet and a higher percentage of fig 6%for 6 weeks and was fed a hypercholesterolemic diet for 2 weeks later. Treatment groups 4-6 were fed a hypercholesterolemic diet for the first 2 weeks and fed a basal diet containing different fig levels 2, 4 and 6%, respectively for 6 weeks. During the experimental period, water was introduced *Ad-Libitum* under hygienic conditions.

At the end of the experiment (8 weeks), rats were fasted over night before scarifying. Blood samples were collected into glass tubes and centrifuged for 15 min at 3,000 rpm. The serum was separated into vacuum tubes and refrigerated at -20 °C till used for biochemical analysis

Biological Evaluation

Body weight was measured weekly while feed consumption was measured daily. Total feed consumption of the experimental period was calculated, body weight gain (BWG) was determined and feed efficiency ratio (FER) were calculated according to Champman *et al.*, (1959).

Biochemical Assays

Serum total cholesterol (TC), triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C) were determined according to Richmond, (1973); Wahlefeld, (1974) and Albers *et al.*, (1983), respectively. Regarding serum low density lipoprotein cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) were calculated according to Friedewald *et al.*, (1972). The atherogenic index was calculated according to Bhardwaj *et al.*, (2013). Malondialdehyde (MDA) and Catalase (CAT) were determined according to Shin, (2009) and Góth, (1991), respectively. Aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP) were assayed using the methods described by IFCC, (1976), IFCC, (1980) and GSCC, (1972), respectively. Histopathological specimens were examined the method described by Banchroft *et al.*, (1996).

Statistical Analysis

Statistical analysis was carried out using the analysis of variance (ANOVA) test with the statistical analysis system SAS, (1996). Results were expressed as mean \pm SE at P < 0.05 significance.

Results and Discussion

The nutritional profile of dried fig fruit has shown its potential health benefits (Table 1). It has been revealed that the dried fruit of fig has carbohydrates as a major component (73.50%) that corresponds to its high energy value (317.78 kcal). Dried fig fruit has a very low amount of fat (0.56%). A moderate amount of protein (4.67%) was found in the dried fruit while dietary fiber content was (3.68%). Fig contains both soluble and insoluble dietary fiber that has a number of health benefits. Dried figs were found to contain moisture (16.63%) and high ash content (4.65%). Moisture content affects the texture, taste, appearance and stability of foods so it is related to the storage attributes of the dried fruit. The ash content is a measure of the total amount of minerals present within a food.

Dried fig is an excellent source of energy, ash, sugar, fiber, carbohydrates. Fig has great nutritive importance due to its content of carbohydrates. Farahnaky, *et al.*, (2009) found that the chemical composition of the dried fig was about 69.1 % of polysaccharides, 4.3% protein; 2.46% fat, 12.1% carbohydrate and 3.1% ash. The

obtained results in our study of the chemical composition either for figs were more or less similar. These results supported the high nutritive value of fig. Phytochemical analysis of dried fig fruit (*F. carica*) included a screening of total phenolics and total flavonoids. As shown in Table 2, total phenolics and total flavonoids were 36 mg GAE/mg sample and 192 mg CE/ mg sample, respectively. Naturally-occurring secondary metabolites present in fruits and vegetables have received widespread attention due to their purported health-promoting properties. Polyphenols have the ability to stabilize the unpaired electron and have an ideal structure to prevent harmful oxidation through free radical scavenging. They have been shown to be more effective antioxidants than vitamins E and C. Flavonoids contribute towards inhibition of cell proliferation, induction of apoptosis and inhibition of enzymes and also have antibacterial and antioxidant effects. Phenolic acids and flavonoids of northernmost fig fruits were also investigated and gallic acid, chlorogenic acid, syringic acid, catechin, epicatechin and rutin were identified. Therefore, total phenolics and flavonoids content of fig extract were estimated and were found to be in moderate amounts. Total phenols and flavonoids of dried figs were recorded in Table (2). Dried fig has the highest concentration of total flavonoids. Antioxidants act as free radicals scavengers related to various diseases, heart diseases, Alzheimer's and Parkinson's disease.

Regarding FI as shown in Table (3) hypercholesterolemic group (+ve control) was increased compared with the healthy group (-ve control) with mean values of 18.24 vs 17.78g/d, respectively. Feed intake decreased in protective group (G3) compared with the hypercholesterolemic group (+ve) with a mean value of 18.01vs18.24g/d, respectively. Whereas, treated groups 4 - 6 which fed on a diet supplemented with dried figs (2, 4 and 6%) decreased compared to the positive control group. Feed intake in group 5 was higher than protective and other treatment groups with mean value of 18.07g/d.

The mean values of body weight gain of the +ve control group was significantly increased ($P < 0.05$), compared to the negative control group 137.00 ± 08.34 vs 90.60 ± 05.93 g, respectively. Non-significant change in body weight gain body weight gain was observed in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values 136.80 ± 07.29 vs 137.00 ± 08.34 , respectively. Body weight gain decreased significantly ($P < 0.05$) in treatment groups 4 and 6 which fed on a diet supplemented with dried figs (2 and 6%) compared to the positive control group with mean values 115.00 ± 10.40 and 122.80 ± 09.23 vs 137.00 ± 08.34 g, respectively. Whereas, group 5 fed on dried figs at level 4% was increased compared with +ve control group with mean values 143.00 ± 05.26 vs 137.00 ± 08.34 , respectively.

Feed efficiency ratio was significantly increased ($P \leq 0.05$) in the +ve control group compared to the (-ve) control with mean values 07.51 ± 00.46 vs 05.09 ± 00.33 , respectively. Non-significant change in FER was observed in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 07.59 ± 00.40 vs 07.51 ± 00.46 , respectively. Feed efficiency ratio was decreased significantly ($P < 0.05$) in treatment groups 4 and 6 which fed on diet supplemented with dried fig 2 and 6%, compared to the positive control group with mean values 06.41 ± 00.58 and 06.89 ± 00.52 vs 07.51 ± 00.46 , respectively. FER of Group which treating with dried figs at level (4%) recorded non-significant

difference compared with +ve control group with mean values 07.91 ± 00.29 vs 07.51 ± 00.46 .

There was an increase in body weight gain, feed intake and feed efficiency ratio (FER) for the positive control group compared to the negative control group. This may be due to the high caloric content of this diet. Milagro *et al.*, (2006) reported that animals fed on the high fat diet showed higher body weight gain and increased energy intake compared with those on the standard-fat diet. This increase in each of the body weight gain, feed intake and FER for the positive control group was more or less normalized in the groups that were fed on the hypercholesterolemic diets, which were supplemented by either 2 or 4 or 6% fig powder and became near the values recorded for the negative control group. The addition of these items to the hypercholesterolemic diet exerted a reduction in the feed intake for these groups and hence decreased the gain in body weight compared to that of the positive control group.

These research results are in agreement with the findings by El-Shobakai *et al.*, 2010, who found that rats treated with figs at (2 and 6%) showed decrease values of BWG compared to the positive control group. FER was significantly ($P \leq 0.05$) increased in the +ve control group and other groups compared to the -ve control. Regarding total cholesterol (mg/dl) as shown in Table (4) hypercholesterolemic group (+ve control) was increased compared with the healthy group (-ve control) with mean values of 229.20 ± 01.96 vs 99.90 ± 01.96 , respectively. Cholesterol decreased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 89.00 ± 01.58 vs 229.20 ± 01.96 , respectively. Cholesterol in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried figs 2, 4 and 6% decreased compared to the positive control group with mean values of 80.20 ± 00.86 , 78.20 ± 00.91 and 74.60 ± 02.32 vs 229.20 ± 01.96 , respectively. Whereas the lowest mean value in cholesterol was recorded in group 6 compared to the treatment groups 4 and 5.

The mean values of a triglyceride of the +ve control group was significantly increased ($P \leq 0.05$), compared to the negative control group 242.20 ± 11.43 vs 76.08 ± 05.22 respectively. Triglyceride decreased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 117.20 ± 06.26 vs 242.20 ± 11.43 respectively. Triglycerides in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried figs 2, 4 and 6% decreased compared to the positive control group with mean values, 172.50 ± 09.52 , 134.09 ± 07.08 and 111.30 ± 03.51 vs 242.20 ± 11.43 respectively. Whereas the lowest mean value in triglyceride was recorded in group 6 compared to the treatment groups 5 and 4.

The mean values of low density lipoprotein of the +ve control group was significantly increased ($P \leq 0.05$), compared to the negative control group 147.40 ± 02.68 vs 25.48 ± 01.52 respectively. Low density lipoprotein decreased in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 49.56 ± 01.89 vs 147.40 ± 02.68 respectively. Low density lipoprotein in treatment groups 4, 5 and 6 which fed on diet supplemented with dried fig 2, 4 and 6% decreased compared to positive control group with mean values of, 99.50 ± 03.11 , 73.78 ± 02.40 and 47.14 ± 01.42 vs 147.40 ± 02.68 respectively. Whereas the lowest mean value in low density lipoprotein was

recorded in group 6 compared to the treatment groups 4 and 5 (47.14 ± 01.42 vs 99.50 ± 03.11 and 73.78 ± 02.40).

The mean values of high density lipoprotein of the +ve control group was significantly decreased ($P \leq 0.05$), compared to the negative control group 33.40 ± 02.38 vs 59.20 ± 02.20 respectively. High density lipoprotein increased in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 52.00 ± 04.63 vs 33.40 ± 02.38 respectively. High density lipoprotein in treatment groups 4, 5 and 6 which fed on diet supplemented with dried fig 2, 4 and 6% increased compared to positive control group with mean values, 42.20 ± 04.63 , 44.60 ± 03.26 and 50.20 ± 01.77 vs 33.40 ± 02.38 respectively. Whereas the highest mean value in high density lipoprotein was recorded in group 6 compared to the treatment groups 4 and 5 (50.20 ± 01.77 vs 42.20 ± 04.63 and 44.60 ± 03.26).

The mean values of very low density lipoprotein of the +ve control group was significantly increased ($P \leq 0.05$), compared to the negative control group 48.44 ± 00.23 vs 15.22 ± 00.69 respectively. Very low density lipoprotein decreased in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 23.44 ± 00.18 vs 48.44 ± 00.23 respectively. Very low density lipoprotein in treatment groups 4, 5 and 6 which fed on diet supplemented with dried fig 2, 4 and 6% decreased compared to positive control group with mean values of, 34.50 ± 00.18 , 26.82 ± 02.23 and 22.26 ± 01.10 vs 48.44 ± 00.23 respectively. Whereas the lowest mean value in very low density lipoprotein was recorded in group 6 compared to the treatment groups 4 and 5 (22.26 ± 01.10 vs 34.50 ± 00.18 and 26.82 ± 02.23).

In a study by Mahmoud *et al.*, (2013), who reported an improvement in lipid profile of hypercholesterolemic rats that fed on a diet supplemented with fig this may be due to the presence of antioxidants including; vitamin A, vitamin C and polyphenols in fig. Polyphenols was reported to exert their hypocholesterolemic effect by reducing cholesterol absorption in the intestine or its production by the liver or by stimulation the biliary secretion of cholesterol and cholesterol excretion in the faeces Skottova *et al.*, (2003).

Gorinstein *et al.*, (2002) revealed that polyphenols decreased LDL-C levels and prevent their oxidation in vivo. Lowering TC and LDL-C and improving HDL-C values has been caused a lower risk of CHD Libby *et al.*, (2000), and could Also fasten the removal of cholesterol from peripheral tissues to the liver for catabolism and excretion Young *et al.*, (2004). Moreover, high HDL-C levels may compete with LDL receptor sites on arterial smooth muscle cells and thus inhibit the uptake of LDL, and could protect the LDL against oxidation in vivo because lipids in HDL are preferentially oxidized before those in LDL. Shukla *et al.*, (2004) shown that figs possess antioxidant, hypolipidemic, and hypoglycemic activities. All extracts of fig leaves caused a decrease of serum cholesterol levels, and this effect is dose dependent as reported by Rassouli *et al.*, (2010).

Regarding AI as shown in Table (5) hypercholesterolemic group (+ve control) was significantly increased ($P \leq 0.05$), compared with the healthy group (-ve control) with mean values of 0.86 ± 0.005 vs 0.11 ± 0.001 , respectively. The atherogenic Index decreased in protective group (G3) compared with the hypercholesterolemic

group (+ve) with mean values of 0.35 ± 0.002 vs 0.86 ± 0.005 , respectively. The atherogenic Index in treated groups 4 - 6 which fed on a diet supplemented with dried figs (2,4 and 6%) decreased compared to the positive control group, whereas, group 4 was higher than all protective and other treatment groups with mean values of 0.61 ± 0.002 .

The mean values of cardiac risk ratio of the +ve control group was significantly increased ($P \leq 0.05$), compared to the negative control (G2), 6.86 ± 1.03 vs 1.69 ± 0.02 respectively. CRR decreased significantly ($P \leq 0.05$) in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values 2.40 ± 0.99 VS 6.86 ± 1.03 , respectively. CRR decreased significantly ($P \leq 0.05$) in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried figs (2, 4 and 6%) compared to positive control group with mean values 4.18 ± 1.07 , 3.26 ± 0.82 and 2.38 ± 0.09 vs 6.86 ± 1.03 , respectively, whereas, group 6 fed on dried figs at level 6% was the lowest group compared with the +ve control group with mean values 2.38 ± 0.09 vs 6.86 ± 1.03 , respectively.

LDL-C to HDL-C ratio was significantly increased ($P \leq 0.05$) in the +ve control group compared to the (-ve) control with mean values 4.41 ± 0.098 vs 0.43 ± 0.002 , respectively. LDL-C to HDL-C ratio decreased significantly ($P \leq 0.05$) in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 0.95 ± 0.061 vs 4.41 ± 0.098 , respectively. LDL-C to HDL-C ratio was decreased significantly ($P \leq 0.05$) in treatment groups 4 - 6 which fed on a diet supplemented with dried figs 2- 4- 6%, compared to a positive control group with mean values of 2.36 ± 0.20 , 1.65 ± 0.053 and 0.94 ± 0.004 vs 4.41 ± 0.098 , respectively.

Mean value of atherogenic coefficient (AC) of the +ve control group was significantly increased ($P \leq 0.05$), compared to the negative control (G2), 5.86 ± 0.04 vs 0.69 ± 0.002 respectively. AC decreased significantly ($P \leq 0.05$) in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 1.40 ± 0.001 VS 5.86 ± 0.04 , respectively. AC decreased significantly ($P \leq 0.05$) in treatment groups 4 - 6 which fed on diet supplemented with dried figs (2 - 4 and 6%) compared to positive control group with mean values of 3.18 ± 0.06 , 2.26 ± 0.53 and 1.38 ± 0.04 vs 5.86 ± 0.04 , respectively. Regarding Aspartate aminotransferase (AST) as shown in Table (6) hypercholesterolemic group (+ve control) was increased compared with the healthy group (-ve control) with mean values of 52.25 ± 02.11 vs 36.25 ± 02.24 , respectively.

Aspartate aminotransferase (AST) decreased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values 40.25 ± 02.01 vs 52.25 ± 02.11 , respectively. Aspartate aminotransferase (AST) in treatment groups 4, 5 and 6 which were fed on a diet supplemented with dried figs 2, 4 and 6% decreased compared to a positive control group with mean values 49.50 ± 02.25 , 43.75 ± 02.15 and 39.25 ± 01.39 vs 52.25 ± 02.11 , respectively. Whereas the lowest mean value in Aspartate aminotransferase (AST) was recorded in group 6 compared to the treatment groups 4 and 5.

Regarding Alanine aminotransferase (ALT) as shown in Table (6) hypercholesterolemic group (+ve control) was increased compared with the

healthy group (-ve control) with mean values 54.00 ± 01.76 vs 20.25 ± 00.86 , respectively. Alanine aminotransferase (ALT) decreased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 31.75 ± 00.97 vs 54.00 ± 01.76 , respectively. Alanine aminotransferase (ALT) in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried figs 2, 4 and 6% decreased compared to a positive control group with mean values 47.25 ± 02.67 , 39.25 ± 00.86 and 33.00 ± 02.07 vs 54.00 ± 01.76 , respectively. Whereas the lowest mean value in Alanine aminotransferase (ALT) was recorded in group 6 compared to the treatment groups 4 and 5.

Our results revealed that there were no significant changes in the levels of serum ALT and AST among the groups fed either dried figs at the tested levels. However, rats fed on a mixture of the three tested samples had the highest reduction in liver enzymes as compared to the other group. Mahmoud *et al.*, (2013), observed that a diet supplemented with different levels of figs and sycamore recorded improvement in liver function.

Vitamins A, C and polyphenols found in figs exerted their antioxidant action through stabilizing the membrane of hepatocytes by scavenging the free radicals formed by the hypercholesterolemia thus preventing lipid peroxidation of hepatocyte membranes; consequently, render the activity of AST and ALT near the normal levels Heibatollah *et al.*, (2008).

Regarding creatinine as shown in Table (7) hypercholesterolemic group (+ve control) was increased compared with the healthy group (-ve control) with mean values 01.66 ± 00.0049 vs 00.52 ± 00.04 , respectively. Creatinine decreased in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 00.85 ± 00.02 vs 01.66 ± 00.0049 , respectively. Creatinine in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried figs 2, 4 and 6% decreased compared to the positive control group with mean values of 01.40 ± 00.03 , 00.93 ± 00.04 and 00.79 ± 00.02 vs 01.66 ± 00.0049 , respectively. Whereas the lowest mean value in Creatinine was recorded in group 6 compared to the treatment groups 4 and 5.

Regarding urea as shown in Table (7) hypercholesterolemic group (+ve control) was increased compared with the healthy group (-ve control) with mean values of 62.75 ± 02.52 vs 39.00 ± 01.85 , respectively. Urea decreased in protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 44.25 ± 03.04 vs 62.75 ± 02.52 , respectively. Urea in treatment groups 4, 5 and 6 which fed on diet supplemented with dried fig 2, 4 and 6% decrease compared to positive control group with mean values 59.25 ± 02.84 , 51.50 ± 02.11 and 46.25 ± 03.17 vs 62.75 ± 02.52 , respectively. Whereas the lowest mean value in urea was recorded in group 6 compared to the treatment groups 4 and 5.

Regarding Malondialdehyde as shown in Table (8) hypercholesterolemic group (+ve control) was increased compared with healthy group (-ve control) with mean values 03.43 ± 00.03 vs 00.82 ± 00.01 , respectively. Malondialdehyde decreased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 01.20 ± 00.024 vs 03.43 ± 00.03 , respectively. Malondialdehyde in treatment groups 4, 5 and 6 which fed on a diet supplemented with dried fig 2,

4 and 6% decreased compared to the positive control group with mean values of 02.50 ± 00.02 , 01.74 ± 00.03 and 01.06 ± 00.04 vs 03.43 ± 00.03 , respectively. Whereas the lowest mean value in Malondialdehyde was, recorded in group 6 compared to the treatment groups 4 and 5.

Regarding catalase, the hypercholesterolemic group (+ve control) was decreased compared with the healthy group (-ve control) with mean values 06.75 ± 00.20 vs 14.04 ± 00.14 , respectively. Catalase increased in the protective group (G3) compared with the hypercholesterolemic group (+ve) with mean values of 12.80 ± 00.12 vs 06.75 ± 00.20 , respectively. Catalase in treatment groups 4, 5 and 6 which fed on diet supplemented with dried figs 2, 4 and 6% increase compared to the positive control group with mean values of 10.89 ± 00.24 , 11.47 ± 00.18 and 13.07 ± 00.16 vs 06.75 ± 00.20 , respectively. Whereas the highest mean value in Catalase was recorded in-group 6 compared to the treatment groups 4 and 5. Compared with the present results, Shukla *et al.*, (2004) showed that figs possess antioxidant, hypolipidemic, and hypoglycemic activities. All extracts of fig leaves caused a decrease in serum cholesterol levels, and this effect is dose-dependent as reported by Rassouli *et al.*, (2010).

Table (1): Nutritional constituents of dried figs fruit (*F. carica L*) (g/100g)

Sample	Energy (Kcal/100g)	Total Carbohydrate	Fat	Protein	Dietary Fiber	Moisture	Ash
Dried fig fruit	317.78	73.50	0.56	4.67	3.68	16.63	4.65

Table (2): Total phenols and total flavonoids of dried fig (*F. carica L*)

Phytochemical	Content
Total Phenols	36 mg GAE/mg sample.
Total Flavonoids	192 mg CE/ mg sample.

Table (3): Effect of dried figs on feed intake (FI), body weight gain (BWG) and feed efficiency ratio (FER) of rats with hypercholesterolemia

Groups	FI (g/d)	BWG (g)	FER
Group 1 (-ve)	17.78	90.60 ± 05.93 ^e	05.09 ± 00.33 ^c
Group 2 (+ve)	18.24	137.00 ± 08.34 ^b	07.51 ± 00.46 ^a
Group 3 (6%): Protective group	18.01	136.80 ± 07.29 ^b	07.59 ± 00.40 ^a
Treatment Groups	Gp4 (2%)	17.93	115.00 ± 10.40 ^d
	Gp5 (4%)	18.07	143.00 ± 05.26 ^a
	Gp6 (6%)	17.82	122.80 ± 09.23 ^c

All values represented as Mean \pm SE. Means with different superscript in the same column are significantly different at ($P \leq 0.05$).

Table (4): effect of dried figs on lipid profile of rats with hypercholesterolemia

Groups		TC	TG	HDL	LDL	VLDL
		mg/dl				
Group 1 (-ve)		99.90±01.96 ^e	76.08±05.22 ^e	59.20±02.20 ^a	25.48±01.52 ^e	15.22±00.69 ^e
Group 2 (+ve)		229.20±11.93 ^a	242.20±11.43 ^a	33.40±02.38 ^d	147.40±02.68 ^a	48.44±00.23 ^a
Group 3 (6%): Protective group		125.00±09.58 ^d	117.20±06.26 ^d	52.00±04.63 ^b	49.56±01.89 ^d	23.44±00.18 ^d
Treatment Groups	Gp4 (2%)	176.20±10.86 ^b	172.50±09.52 ^b	42.20±02.37 ^c	99.50±03.11 ^b	34.50±01.74 ^b
	Gp5 (4%)	145.20±07.91 ^c	134.09±07.08 ^c	44.60±03.26 ^c	73.78±02.40 ^c	26.82±02.23 ^c
	Gp6 (6%)	119.60±08.32 ^d	111.30±03.51 ^d	50.20±01.77 ^b	47.14±01.42 ^d	22.26±01.10 ^d

All values represented as Mean± SE. Mean with different superscript in the same column are significantly different at (P≤ 0.05).

Table (5): Effect of dried figs on atherogenic index (AI), cardiac risk ratio (CRR), LDL-C to HDL-C ratio and atherogenic coefficient (AC) of rats with hypercholesterolemia

Groups		AI	CRR	LDL/HDL Ratio	AC
Group 1 (-ve)		0.11±0.001 ^e	1.69±0.02 ^d	0.43±0.002 ^e	0.69±0.002 ^e
Group 2 (+ve)		0.86±0.005 ^a	6.86±1.03 ^a	4.41±0.098 ^a	5.86±0.04 ^a
Gp3 (6%):Protective group		0.35±0.002 ^d	2.40±0.99 ^c	0.95±0.061 ^d	1.40±0.001 ^d
Treatment Groups	Gp4 (2%)	0.61±0.002 ^b	4.18±1.07 ^b	2.36±0.20 ^b	3.18±0.06 ^b
	Gp5 (4%)	0.48±0.001 ^c	3.26±0.82 ^b	1.65±0.053 ^c	2.26±0.53 ^c
	Gp6 (6%)	0.35±0.004 ^d	2.38±0.09 ^c	0.94±0.004 ^d	1.38±0.04 ^d

All values represented as Mean± SE. Mean with different superscript in the same column are significantly different at (P≤ 0.05).

Table (6): Effect of dried figs on aspartate aminotransferase (AST) and alanine aminotransferase (ALT) of rats with hypercholesterolemia

Groups		AST	ALT
		U/L	
Group 1 (-ve)		36.25±02.24 ^e	20.25±00.86 ^e
Group 2 (+ve)		52.25±02.11 ^a	54.00±01.76 ^a
Gp3 (6%):Protective group		40.25±02.01 ^d	31.75±00.97 ^d
Treatment Groups	Gp4 (2%)	49.50±02.25 ^b	47.25±02.67 ^b
	Gp5 (4%)	43.75±02.15 ^c	39.25±00.86 ^c
	Gp6 (6%)	39.25±01.39 ^d	33.00±02.07 ^d

All values represented as Mean± SE. Mean with different superscript in the same column are significantly different at (P≤ 0.05).

Table (7): Effect of dried figs on creatinine and urea of rats with hypercholesterolemia

Groups		Creatinine	Urea
		mg/dL	
Group 1 (-ve)		00.52±00.04 ^e	39.00±01.85 ^e
Group 2 (+ve)		01.66±00.0049 ^a	62.75±02.52 ^a
Gp3 (6%):Protective group		00.85±00.02 ^d	44.25±03.04 ^d
Treatment Groups	Gp4 (2%)	01.40±00.03 ^b	59.25±02.84 ^b
	Gp5 (4%)	00.93±00.04 ^c	51.50±02.11 ^c
	Gp6 (6%)	00.79±00.02 ^d	46.25±03.17 ^d

All values represented as Mean± SE. Mean with different superscript in the same column are significantly different at (P≤ 0.05).

Table (8): Effect of dried figs on malondialdehyde (MDA) and catalase (CAT) of rats with hypercholesterolemia

Groups		MDA(nmol/mg)	CAT(U/mg)
Group 1 (-ve)		00.82±00.01 ^e	14.04±00.14 ^a
Group 2 (+ve)		03.43±00.03 ^a	06.75±00.20 ^d
Gp3(6%):Protective group		01.20±00.024 ^d	12.80±00.12 ^b
Treatment Groups	Gp4 (2%)	02.50±00.02 ^b	10.89±00.24 ^c
	Gp5 (4%)	01.74±00.03 ^c	11.47±00.18 ^c
	Gp6 (6%)	01.06±00.04 ^d	13.07±00.16 ^b

All values represented as Mean± SE. Mean with different superscript in the same column are significantly different at (P≤ 0.05).

Histopathological examination of aorta

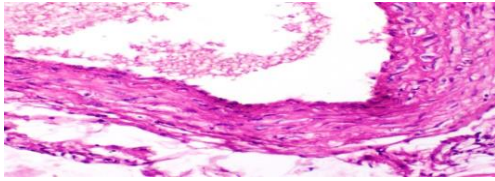


Photo (1): Aorta of rat from group 1 showing the normal histological structure with no histopathological changes (H & E X 400).

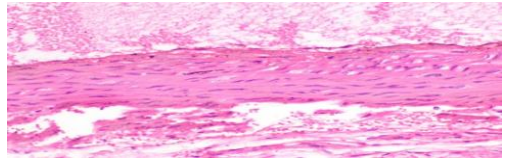


Photo (2): Aorta of rat from group 1 showing the normal histological structure with no histopathological changes (H & E X 400).

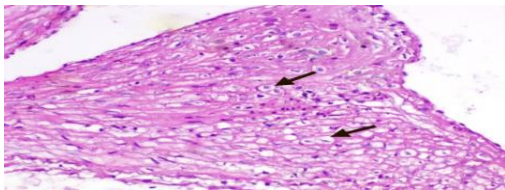


Photo (3): Aorta of rat from group 2 showing atheromatous plaque with necrosis of tunica media and foam cells aggregation (H & E X 400).

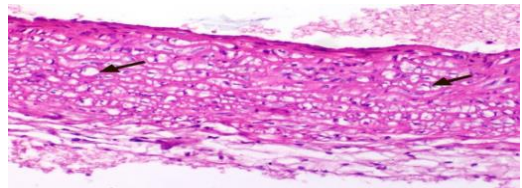


Photo (4): Aorta of rat from group 2 showing marked vacuolizations of cells of tunica media (H & E X 400).

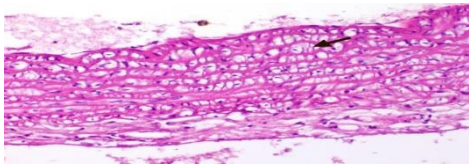


Photo (5): Aorta of rat from group 2 showing marked vacuolizations of cells of tunica media (H & E X 400).

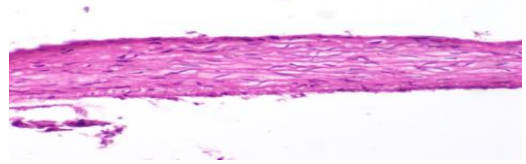
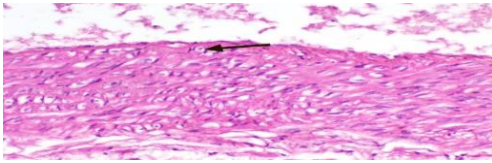


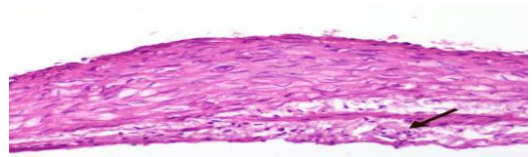
Photo (6): Aorta of rat from group 3 showing no histopathological alterations (H & E X 400).

Photo (7): Aorta of rat from group 3



showing slight vacuolizations of cells of tunica media (H & E X 400).

Photo (8): Aorta of rat from group 3 showing



few inflammatory cells infiltration (H & E X 400).

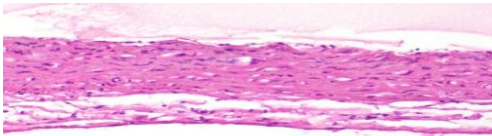


Photo (9): Aorta of rat from group 4 showing no histopathological alterations (H & E X 400).

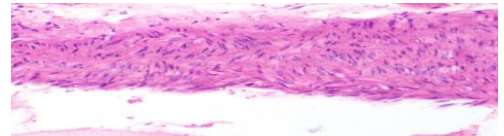
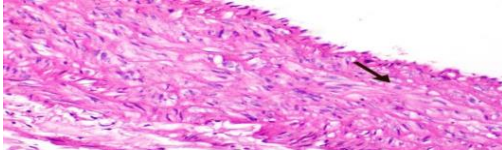


Photo (10): Aorta of rat from group 4 showing no histopathological alterations (H & E X 400).

Photo (11): Aorta of rat from group 4



showing slight vacuolizations of some cells of tunica media (H & E X 400).

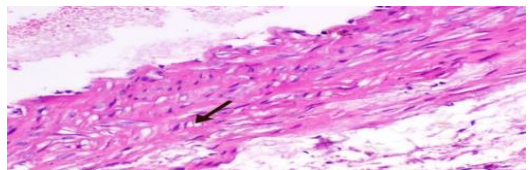
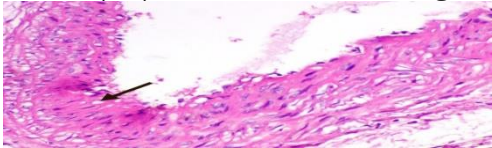


Photo (12): Aorta of rat from group 5 showing slight vacuolizations of cells of tunica media (H & E X 400).

Photo (13): Aorta of rat from group 5



showing vacuolizations of cells of tunica media (H & E X 400).

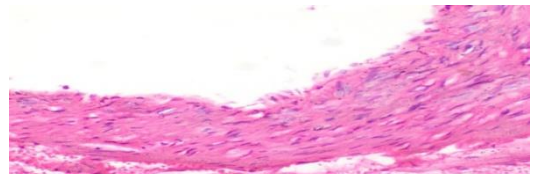


Photo (14): Aorta of rat from group 6 showing no histopathological alterations (H & E X 400).

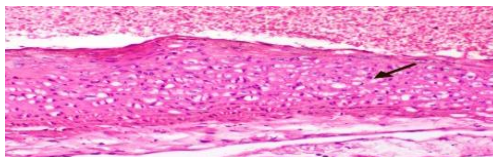


Photo (15): Aorta of rat from group 6 showing vacuolizations of cells of tunica media (H & E X 400).

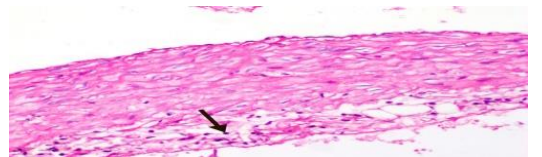


Photo (16): Aorta of rat from group 6 showing few inflammatory cells infiltration (H & E X 400).

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