Study of the effect of feeding two cultivars of purslane (*Portulaca oleracea* l.) On lipid profile and lipid peroxidation of adult male Sprague Dawley rats

دراسة تأثير إطعام نوعين من نبات البقلة على مستوى دهون الدم وفوق أكسدتها لذكورالجرذان من نوع سبراغ داولي

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Abstract

This study was conducted to evaluate the effect of feeding purslane on lipid profile and lipid peroxidation in adult male Sprague Dawley rats fed high cholesterol diet. Wild and cultivated purslane were collected, dried and milled to be used in rat diets. Forty male Sprague-Dawley rats at 9 weeks of age, weighing (200-250g) were randomly divided into four experimental groups, 10 rats each, and fed either normal diet (group 1) or high cholesterol diet (HCD) (1% cholesterol) (groups 2, 3 and 4) for 4 weeks, at the end of the fourth week, the prepared wild and cultivated purslane plants were administered at 2.5% to (groups 3 and 4, respectively) for another 8 weeks. The addition of wild and cultivated purslane significantly lowered the serum cholesterol levels in groups 3 and 4 to 133.1 ± 34.5 and 130.9 ± 21.2 mg/dl, respectively, in comparison to HCD group without purslane (169.8 ± 57.9), and low-density lipoprotein (LDL) levels (96.3 ± 32.8 and 95.4 ± 20.1 mg/dl) in comparison to HCD group without purslane (132.5 ± 62.5). Blood peroxidation (MDA) values in wild and cultivated purslane groups (10.9 ± 1.6 and 10.9 ± 2.8 nmol/ml) were significantly lower than the MDA

level in groups 1 and 2 (14.3±3.0 and 15.8±5.0 nmol/ml respectively). In conclusion, the addition of purslane to the diet of rats decreased serum cholesterol, LDL and lipid peroxidation levels indicating that the plant could have important medical implications.

Keywords: Purslane, *Portulaca oleracea* L., Sprague Dawley, Lipids.

ملخص

هدفت الدراسة إلى معرفة تاثير الأجزاء المأكولة من نبات البقلة على فوق أكسدة الدهون ودهنيات الدم في جرذان من نوع سبراغ - داولي مغذاة بوجبة عالية الكولسترول. تم جمع نبات البقلة البري والمزروع وتجفيفهما وطحنهما للإستعمال في التجربة الحيوانية، وتم إجراء التجربة كما يلي: لقد تم إحضار 40 من الجرذان على عمر 9 أسابيع ووزن (200-250 غرام) وتقسيمها إلى أربع مجموعات في كل مجموعة 10 جرذان، وقد تم إطعام المجموعة الأولى وهي الضابطة السلبية بوجبة عادية (NCD)، أما المجموعة الثانية (الضابطة الإيجابية) والمجموعة الثالثة والرابعة (مجموعتا الاختبار) فقد تم إطعامهما وجبة عالية الكولسترول (HCD) لمدة 4 أسابيع، جرى بعدها إدخال نبات البقلة البري المجفف المطحون بنسبة (2.5%) لمدة 8 أسابيع إضافية إلى وجبة المجموعة الثالثة، وإدخال نبات البقلة المزروع إلى وجبة طعام المجموعة الرابعة وبنفس النسبة والمدة السابقتي الذكر. وجد في هذه الدراسة أن قيم الوزن الإبتدائي والنهائي والوزن المكتسب ونسبة كفاءة التحويل الغذائي لجميع المجموعات كـانت متقاربة دون وجود فروق معنـوية، كما أظهرت هذه الدراسة أن إضافة البقلة البرية والمزروعة قد خفضت قيمة كولسترول مصل الدم إلى (133.1 ± 34.5 و130.9 ± 21.2 مليغرام لكل ديسيليتر) على التوالي مقارنة بالمجموعة الضابطة الإيجابية التي كانت قيمة الكولسترول لها (169.8 ± 57.9 مليغرام لكل ديسيليتر) بفرق معنوي على مستوى$P<0.05$، كما وأظهرت النتائج أن إضافة البقلة البرية والمزروعة قد خفضت قيمة البروتين الدهني منخفض الكثافة (LDL) معنوياً $P<0.05$ حيث كانت (96.3 ± 32.8 و 95.4 ± 20.1 مليغرام لكل ديسيليتر) على التوالي مقارنة مع المجموعة الضابطة الإيجابية التي كانت قيمتها (132.5 ± 62.5 مليغرام لكل ديسيليتر). كما وبينت هذه الدراسة أن إضافة البقلة البرية والمزروعة أدت إلى انخفاض قيم أكسدة دهون الدم (المالونداياليديهيد) وقيمتها (10.9 ± 1.6 و 10.9 ± 2.8) على التوالي مقارنة مع نفس المجموعة الضابطة الإيجابية (15.8±5.0نانومول لكل مل)، بينما لم يكن هناك ثمة تأثير للنبات المضاف على كل من الدهون الثلاثية والبروتين الدهني عالي الكثافة. وخلصت هذه الدراسة إلى أن إضافة البقلة بنوعيها له تاثير إيجابي على تقليل الكرب التأكسدي لدى الجرذان المغذاة بوجبة عالية الكولسترول إذ خفضت كلاً من كولسترول مصل الدم والبروتين الدهني منخفض الكثافة (LDL) وأكسدة دهون الدم (MDA) مما يشير إلى الأهمية الطبية لهذه النبتة.

الكلمات المفتاحية: البقلة، جرذان السبراغ داولي، دهون الدم، فوق أكسدة الدهون.

Introduction

Dyslipidemia refers to the abnormal levels of lipid and lipoproteins in the blood including low density lipoprotein (LDL), high density lipoprotein (HDL), total cholesterol and triglycerides (Salonen *et al*., 1998, p. 270). Dyslipidemia is associated with oxidative stress in the endothelium which promotes pro-inflammatory processes (Nappo *et al*., 2002, p. 1145). Researchers have found that type of fat consumed, obesity, and sedentary life activities are the major risk factors associated with dyslipidemia which is a key independent modifiable risk factor for cardiovascular diseases (Basulaiman *et al*., 2014, p. 801; Joshi *et al*., 2014, p. 96).

Oxidative stress is a case of imbalance between the production and neutralization of free radicals in the body. It is a major factor for several degenerative and inflammatory diseases (Chanwitheesuk *et al*., 2004, p.491). It causes tissue damage due to an imbalance between reactive oxygen species generation and scavenging systems which lead to the oxidation of lipid and other body compounds. Therefore, oxidative stress has been implicated in the pathophysiology of many severe disorders such as cancer, cardiovascular diseases, neurological disorders, liver disorders, hypertension, arthritis, autoimmune diseases, diabetes and aging process (Kratchanova *et al.,* 2014, p. 491; Tawaha *et al*., 2007, p. 1372).

Higher plants contain a variety of other phytochemicals such as polyphenols in all of their parts that exert antioxidant activity (Zhang and Tsao, 2016, p. 33). Wild edible plants are rich in such compounds. Wild and cultivated edible plants could be considered as a source of bioactive compounds such as polyphenols which are linked to a decrease in oxidative stress (Romojaro *et al*., 2013, p. 944). Many of these plants have been recognized to have beneficial health impacts such as anti-inflammatory, antimicrobial, and hypolipidemic effects (Wojdylo *et al*., 2007).

Research regarding wild edible plants concentrates on determining the nutritive value, preservation methods and health impacts of the

plants. Furthermore, measuring antioxidant capacity and polyphenolic contents is also crucial (Meda *et al*., 2008, p. 571). In Jordan and other countries, wild edible plants are consumed in different ways and for different cultural reasons (Tukan *et al*., 1998, p. 225). Although many studies on the nutritive value and polyphenol content of some of the wild edible plants in the area were conducted, information regarding antioxidant capacity and phenolic content of wild edible plants in Jordan and the surrounding region is rare and not documented (Tawaha *et al*, 2007, p. 1372).

Purslane (*Portulaca oleracea* L.) is a wide-spread plant that was listed by the World Health Organization as one of the most used medicinal plants and a culinary herb in many countries. It is a cosmopolitan annual weed that has been used as a pharmaceutical and edible plant that grows in warm and moist regions of the northern hemisphere especially in China, India, the Middle East, Africa, Europe and America (Osma *et al*., 2014, p. 2181). It was classified as the eighth most commonly distributed plant in the world and is eaten throughout Europe and Asia either raw in a salad or cooked. Purslane forms part of the Mediterranean diet, especially in Greece and Turkey and is appreciated for its tangy or acid taste like spinach (Moreau *et al*., 2009, p. 303).

In addition to its nutritional and metabolic benefits, purslane has been used as a medicine by many cultures in different parts of the world for its antioxidant (Dubey *et al*., 2013, p. 15), antimicrobial (Lim *et al*., 2007, p. 734), hypoglycemic (Okwuasaba *et al*., 1986, p. 139) and hypocholesterolemic (Cui *et al*., 2005, p. 92) properties. Two types of purslane are known in many countries: the wild cultivar, which grows where water is available, and the cultivated (agronomic) cultivar. Both types of purslane are present in many parts of Jordan including our study area (Amman) (Osma *et al*., 2014, p. 2181). The objectives of the current study were to evaluate the effect of wild and cultivated purslane on lipid peroxidation and lipid profile in rats.

Methodology

Plant collection

The selected wild and cultivated purslane plants were collected during late spring (May, 2018) from the Amman area. The plants were cleaned and the edible parts (flowers, leaves, puds and 5 cm of the stem) were separated and dried in shade under low temperature (20ºC to 30ºC) (Shanker *et al*., 2015, p. 6631). Samples were ground and transferred to glass containers and stored in the refrigerator at 4°C till analyzed and used in the animal experiment.

Proximate analysis

The percent of each of moisture, ash, protein, fat and fiber in both wild and cultivated purslane were determined using standard proximate analysis procedures as described by the Official Methods of Analysis (AOAC) . The analysis of the food samples was performed in triplicate and average values are given. The carbohydrate or the nitrogen-free extract (NFE) percent was calculated by subtracting the sum of percentages of (moisture, ash, protein, fat and fiber) from 100 (Latimer, 2012).

Animal experiment

Study design: A completely randomized design, (CRD) was used to determine the effect of wild and cultivated purslane on lipid peroxidation by using malondialdehyde (MDA) as an indicator. Besides, the lipid profile (triglycerides, total cholesterol, LDL-C and HDL-C) in male Sprague Dawley rats (200-250g wt; 8 weeks age) fed on high cholesterol diet were determined (Sharma and Sahu, 2016, p. 29).

Experimental animals: Forty adult male Sprague Dawley rats (8 weeks, 200-250 g) were obtained from the central animal house unit at The Jordan University of Science and Technology (Irbid, Jordan). Animals were housed under standard conditions (22ºC± 2ºC and 45-55% relative humidity, with a 12:12 h light / dark cycle) and were acclimatized for one week before the experiment (Sharma and Sahu, 2016, p. 29). During this week, animals were fed a stock diet and tap

water. Diets were provided in glass jars and water was supplied *ad libitum*. Each rat was housed in one cage. The forty rats were randomized to 4 groups, 10 rats each as follows:

- Group 1: Normal Diet – (-ve control group)
- Group 2: High Cholesterol diet (1%) – (+ve control group)
- Group 3: High Cholesterol diet (1%) with 2.5% wild purslane
- Group 4: High Cholesterol diet (1%) with 2.5% cultivated purslane

Components of these diets are shown in table 1 and proximate analysis for wild and cultivated purslane is shown in table 2.

The test plant was introduced in the diet of the test groups for another 8 weeks. Finally, all rats were sacrificed and blood samples were collected by cardiac puncture and centrifuged immediately to obtain serum that was stored at -18ºC until analysis (Campbell *et al*., 2016, p. 219; Sharma and Sahu, 2016, p. 29).

Rats' weights were taken each week. Also, feed intake was calculated weekly by weighing the diet that remained in the jars and estimating the spilled food by msubtracting the value from the amount of feed provided. Feed intake, weight gain and feed conversion ratio (FCR) were calculated as shown in these equations:

- Feed intake(g) = feed provided (g) – (remaining feed + spilled feed)
- Weight gain= Final weight of rat (g) – Initial weight of rat (g)
- FCR= weight of feed intake (g) / Weight gain (g)

Diets: The normal cholesterol diet (NCD) was prepared according to the American Institute of Nutrition (AIN) standard diet for nutritional and toxicological research with modification using egg white as a source of protein instead of casein as shown in table 1 (Reeves, 1997, p. 838).

Table (1): Components of test diets for the different experimental groups per one kilogram.

	-ve control NCD[2]	+ve control (HCD[3])	HCD with wild purslane	HCD with cultivated purslane
Corn Starch (g)	610.69	610.69	600	600
Egg White (g)	140	140	135	135
Sucrose (g)	100	100	100	100
Soybean oil (g)	40	30	29	29
Cellulose (g)	50	50	50	50
Mineral Mix (g)	35	35	35	35
Vitamin Mix (g)	10	10	10	10
L-Cysteine (g)	1.8	1.8	1.8	1.8
Biotin Premix (g)	10	10	10	10
Choline Bitartrate (g)	2.5	2.5	2.5	2.5
TBHQ (mg) [1]	8	8	8	8
Cholesterol (g)	0	10	10	10
Purslane (g)	0	0	25	25
Total energy (Kcal)	3896	3896	3896	3896

[1]TBHQ: Tertiary Butylhydroquinone
[2]Normal Cholesterol Diet
[3]High Cholesterol Diet

Table (2): Proximate analysis of the dried purslane.

	Moisture%	Ash%	Protein%	Fat%	Fiber%	NFE[1]%
Wild	5.1 ± 0.1	16.6 ± 0.5	22.0 ± 0.1	4.3 ± 0.3	8.0 ± 0.6	44.0 ± 0.3
Cultivated	6.4 ± 0.2	17.0 ± 0.4	21.0 ± 0.0	4.1 ± 0.2	9.5 ± 0.7	42.0 ± 0.3

[1]NFE: Nitrogen Free Extract

The high cholesterol diet (HCD) was prepared by adding 10 g cholesterol to three groups in a concentration of 10 g/ kg diet (1% cholesterol) (Wang *et al*., 2012, p. 8886) as shown in table 1. Tertiary butylhydroquinone (TBHQ) was added to all of the diets (2 mg for each10 g fat) to protect from oxidation (Reeves, 1997, p. 838).

Biochemical analysis

Lipid profile: An automated clinical analyzer (ARCHITECT plus, Serial number: i1SR56522, Abbott, Germany) was used for the analysis of serum lipids in Mega Lab Medical Laboratory (Amman, Jordan). The analyzer was calibrated before performing the analyses tests; calibration of the analyzer for triglyceride (TG), total cholesterol (TC), Low-density lipoprotein (LDL) and High-density lipoprotein (HDL) was done according to the manufacturer's instructions.

Lipid peroxidation assay: Lipid peroxidation was tested by using malondialdehyde (MDA) as an indicator using thiobarbituric acid. The reactive substance assay depends on the reaction of MDA with thiobarbituric acid to produce a colored product that can be measured at 532 nm.

For this aim, 0.5 ml of the serum sample was mixed with 2.5ml of 10% trichloroacetic acid (TCA) solution in a centrifuge tube, and then the tube was immersed in a boiling water bath for 15 minutes. After that, tubes were cooled in water and then centrifuged at 3000 rpm for 5 minutes (HERMLE Z200A, LaborTechnik, Wehingen, Germany). After that, 2 ml of the liquid supernatant was added to 1ml of the 0.67% thiobarbituric acid (TBA) solution in another test tube. The tube was put again in a boiling water bath for 15 minutes followed by cooling in tap water. The absorbance was estimated spectroscopically at 532 nm against blank. The results were given as MDA equivalent (Esterbauer and Cheeseman, 1990).

Statistical analysis

Statistical analysis of the data was performed using the Statistical Package for the Social Science (SPSS) version 24. The data were

expressed as mean ± standard error of the mean (SEM). Analysis of variance (ANOVA) coupled with LSD test was used to determine any significant differences between the variable means of the study groups. The level of significance was at ($P \leq 0.05$).

RESULTS

Body weight and feed conversion ratio (FCR)

Table (3) shows the mean and the standard error of the mean for initial and final body weight (g), total weight gain (g), total feed Intake (g) and feed conversion ratio for the studied groups. There was no significant difference ($P>0.05$) between groups regarding initial weight, final weight, total weight gains and feed conversion ratio. The total feed intake for group 4 (HCD which was on the cultivated plant) has a significant difference ($P<0.05$) compared to groups 1 and 2 which did not receive the plant. There was no significant difference between group 4 (1740.7 ± 197.0) and group 3 (1624.3 ± 96.7). In addition, group 3 (HCD with wild plant) did not differ significantly ($P>0.05$) from normal diet group and high cholesterol diet groups.

Table (3): Initial and final body weight, body weight gain, total feed intake and feed conversion ratio among experimental groups.

Group Description	Initial Weight (g)	Final Weight (g)	Total Weight Gain (g)	Total Feed Intake (g)	Feed Conversion Ratio
1. Normal Diet	265.6 ± 21.3 [a]	403.8 ± 23.4 [a]	138.2 ± 25.2 [a]	1565.2 ± 92.9 [a]	11.7 ± 2.1 [a]
2. HCD Diet	264.7 ± 20.3 [a]	398.0 ± 41.6 [a]	133.4 ± 32.5 [a]	1558.7 ± 170.8 [a]	12.1 ± 2.3 [a]
3. HCD Diet with wild plant	264.2 ± 20.5 [a]	387.5 ± 26.1 [a]	123.3 ± 31.3 [a]	1624.3 ± 96.7 [ab]	13.7 ± 2.3 [a]
4. HCD Diet with cultivated plant	263.9 ± 21.6 [a]	409.1 ± 58.6 [a]	145.2 ± 44.6 [a]	1740.7 ± 197.0 [b]	12.7 ± 2.9 [a]

*letters for significance in columns.

Biochemical analyses

Blood lipid profile: Table (4) shows the means of serum lipids levels in (mg/dl) for rats fed the different experimental diets. There was a significant difference in blood cholesterol levels ($P<0.05$) between the

high cholesterol diet group without purslane (169.8 ± 57.9 mg/dl) and the normal diet group (88.3 ± 18.2 mg/dl). The addition of the wild and cultivated purslane to the diet (groups 3 and 4) (133.1 ± 34.5 and 130.9 ± 21.2 mg/dl, respectively) resulted in significantly lower cholesterol value ($P<0.05$) in comparison with group 2 which did not receive plant in the diet, while there was no significant difference ($P>0.05$) between wild and cultivated groups in blood cholesterol levels.

Regarding triglycerides, there was no significant difference ($P>0.05$) between the tested groups (wild and cultivated plant groups) and control groups (normal diet group and HCD diet group).

LDL serum levels in high cholesterol diet group (132.5 ± 62.5 mg/dl) was significantly different ($P<0.05$) from the normal diet group (44.1 ± 12.3 mg/dl). The addition of purslane to the diet in group 3 (wild purslane group) (96.3 ± 32.8 mg/dl) and group 4 (cultivated purslane group) (95.4 ± 20.1 mg/dl) resulted in lowering the LDL significantly ($P<0.05$) compared with those which did not receive the plant in their diet (group 2). There was no significant difference ($P>0.05$) between the rat groups which received the wild and cultivated purslane regarding the LDL level.

Concerning HDL, there was a significant difference ($P<0.05$) between group 1 (normal diet) (25.5 ± 4.6 mg/dl) and all of the other groups (18.4 ± 2.7, 18.6 ± 1.2 and 19.0 ± 3.1 mg/dl for groups 2, 3 and 4, respectively). However, there were no significant differences among groups 2, 3 and 4.

Lipid peroxidation (MDA) assay: Table (4) shows the mean and the standard error of the mean for MDA concentration levels in the studied groups. MDA values were calculated as nmol MDA / ml. There was no significant difference ($P>0.05$) between group 1 (14.3 ± 3.0) and group 2 (15.8 ± 5.0). Also, there was no significant difference ($P>0.05$) between group 3 (wild plant) (10.9 ± 1.6) and group 4 (cultivated group) (10.9 ± 2.8). However, there was a significant difference ($P<0.05$) between the two test groups in comparison with the groups which were not fed the plant (group 1 and 2).

Table (4): Lipid profile (mg/ dl) and serum malondialdehyde concentration (MDA) (nmol/ml) among experimental groups.

Group Description	Lipid Profile (mg/dl)				MDA nmol/ml
	Cholesterol	TG	LDL	HDL	
1. Normal Diet	88.3 ± 18.2 [a]	112.5 ± 67.1 [a]	44.1 ± 12.3 [a]	25.5 ± 4.6 [a]	14.3 ± 3.0 [a]
2. HCD Diet	169.8 ± 57.9 [b]	113.5 ± 40.9 [a]	132.5 ± 62.5 [b]	18.4 ± 2.7 [b]	15.8 ± 5.0 [a]
3. HCD Diet with wild plant	133.1 ± 34.5 [c]	117.7 ± 51.1 [a]	96.3 ± 32.8 [c]	18.6 ± 1.2 [b]	10.9 ± 1.6 [b]
4. HCD Diet with cultivated plant	130.9 ± 21.2 [c]	99.2 ± 21.9 [a]	95.4 ± 20.1 [c]	19.0 ± 3.1 [b]	10.9 ± 2.8 [b]

*letters for significance in columns

Discussion

Body weight and feed conversion ratio (FCR)

Body weight can be considered as a marker for food utilization, while total food intake is an indicator of diet acceptability and palatability by experimental rats. As shown in table (3), there were no significant differences (P>0.05) among the four study groups regarding the initial weight and final body weight and body weight gain. This could be attributed to the iso-caloric diet and careful randomization for all rats. Our findings are in agreement with those of (Moraes *et al*., 2012, p. 553; Lee *et al*., 2011, p. 202 and Miras *et al*., 2014, p. 302).

Regarding total food intake, there were no significant differences (P>0.05) among groups (1, 2 and 3) the normal diet group, the high cholesterol group and the wild purslane groups respectively. While cultivated purslane group differed significantly from the two control groups (P<0.05) which may be reflecting better acceptance and palatability of that cultivar. Regarding the feed conversion ratio (FCR) there were no significant differences (p>0.05) among all of the groups; the same result was reported by Lee *et al.,* (2011, p. 202) and this may be due to the same caloric content of different diets and good randomization of rats among the groups.

Lipid profile

Plasma cholesterol is of major importance in the pathogenesis of atherosclerosis and understanding cholesterol metabolism has enabled the

development of drugs and dietary treatments to reduce risk for cardiovascular events. Hence, it is important to explore dietary influences on plasma cholesterol and lipids. From Table 4, it can be shown that there was a significant difference ($P<0.05$) in serum cholesterol value in blood of the experimented rats in normal diet group and high cholesterol diet group; this is expected since cholesterol was added in the diet to group 2 (HCD) in a 1% level. Barakat *et al.,* (2011, p. 361) reported similar results. In this study adding 10 grams of cholesterol to 1 kg of (HCD) raised blood cholesterol by 92%.

Besides, there was a significant difference ($P<0.05$) between the purslane fed groups and the high cholesterol diet group showing a plant effect. This indicated that both wild and cultivated purslane exerted a positive effect on decreasing elevated serum cholesterol levels by 22% and 23% in wild and cultivated purslane, respectively. Similar results were obtained by other authors (Djellouli *et al*., 2018, p. 1492; Lee *et al.*, 2011, p. 202). In this study, purslane was added to a level of 2.5 % to both test groups leading to decreased total cholesterol level in the blood. It is expected that if we increase the concentration of wild and cultivated purslane in the diet to 5% and 10 %, this will be reflected in the percentage of cholesterol decrement in rat blood as was found by Lee *et al*, (2011, p. 202).

Ghorbani *et al*, (2013, p. 2354) suggested that purslane may prevent oxidative stress in broilers. Gallo *et al*, (2017, p. 64) attributed this effect to soluble fibers in purslane. Antioxidants such as polyphenols may exert this effect (Ngamukote *et al*., 2011, p. 5054). Those authors concluded that polyphenolic compounds had cholesterol-lowering activity by inhibiting pancreatic cholesterol esterase, binding bile acids, and decreasing cholesterol solubility in micelles which may lead to delaying cholesterol absorption. This hypothesis is consistent with that of Heidrich *et al*, (2004, p. 5) who concluded that inhibitors of cholesterol esterase may be useful therapeutics for decreasing cholesterol blood levels.

Low density lipoprotein cholesterol was significantly increased ($P<0.05$) in the cholesterol added groups (2, 3 and 4) in comparison with group 1 which received a normal diet. Also, there was a significant

difference (P<0.05) in LDL levels between the purslane fed groups (wild and cultivated) and the high cholesterol group (group 2). This difference shows the effect of wild and cultivated plants on deceasing (LDL) level. Accordingly, wild and cultivated purslane decreased LDL blood levels in the experimented rats by 27% and 28 %, respectively. Similar results were achieved by other studies; Movahedian *et al.* (2007, p. 285) fed purslane to rabbits which significantly lowered blood levels of LDL compared to the positive control group.

Regarding high density lipoprotein (HDL), there was a significant difference (P<0.05) between the normal diet group and the high cholesterol diet group as expected since cholesterol was added to the diet of this group (Lee *et al*., 2011, p. 202). However, there was no significant difference (P>0.05) in HDL between the HCD group and the two test groups to which purslane was added. This could be due to the low levels of purslane used in this study (2.5%). Esmaillzadeh *et al*, (2015, p. 47) also found the same result where the addition of purslane could not affect high -density lipoprotein cholesterol levels in humans.

Regarding triglycerides, there were no significant differences (p>0.05) among groups. Thus, the addition of 1% cholesterol to normal diet did not cause an increment in triglyceride levels and using purslane in a concentration of 2.5% could not lower TG blood levels in the test groups. However, the addition of purslane in higher concentrations (5% and 10% of the diet) could make a significant decrease in TG levels in the experimented rats as was found by Lee *et al*, (2011, p. 202).

Blood peroxidation

Blood peroxidation or Malondialdehyde (MDA) is one of the final products of polyunsaturated fatty acid peroxidation in the cells. An increase in free radicals causes overproduction of MDA. Malondialdehyde level is commonly taken as a marker of oxidative stress and antioxidant status. Table 4 shows a significant difference (P<0.05) between the two groups which were fed purslane and the control groups (normal diet and high cholesterol diet). This significant difference reflects the effect of plant protection on blood lipids and agrees with

those of Niharika *et al*, (2016, p. 1) and of Zidan *et al*., (2016, p. 1). This finding may indicate the positive effect of purslane in giving protection to blood lipids. Wild and cultivated purslane decreased MDA values by 31% when compared with the control groups.

Conclusion: The addition of purslane to the diet of Sprague Dawley rats decreased the levels of total serum cholesterol and LDL. In addition, it decreased lipid peroxidation as indicated by lowered serum malondialdehye level. The results indicate that purslane could have important health implications.

Study limitations: A few limitations should be mentioned in this study. Using plant concentrations of 2.5% did not reveal any significant effects on HDL and TG in test groups. Besides, the bioavailability of the plant functional components could have been low because of using the dry plant which has cell wall-bound phenolic compounds.

Conflict of interest: The authors declare no conflict of interest.

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