

RESEARCH ARTICLE

Impactful effect of the avocado (*Persea americana*) in improving the biological and health status of hyperlipidemic rats

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Abstract:

Background: Cardiovascular diseases represent a major worldwide health issue, and avocados, abundant in monounsaturated fats and bioactive substances, may enhance heart health by affecting lipid profiles and additional risk determinants. **Objective:** Determine the effectiveness of different concentrations of avocado in improving the health of hyperlipidemic rats. **Materials and methods:** Twenty-four male Sprague-Dawley albino rats, aged 10 weeks, weighing 150 ± 10 g, were split into 4 groups. The experiment was carried out in two periods. In the first period (three weeks), the first group was fed as a control group and was fed a control diet, while the other groups were fed the hyperlipidemic diets. In the second period (6 weeks), one of the hyperlipidemic rats fed on a hyperlipidemic diet (10% animal fat and 1% cholesterol). While the other groups were fed on a hyperlipidemic diet supplemented with different levels of avocado (*Persea americana*), while one group was given a regular diet to act as a control positive. The experiment concluded with a blood sample and biochemical examination of the excised organs. **Results:** Serum free fatty acids, Serum total cholesterol, Serum phospholipids and Serum triglycerides there were significant differences ($p < 0.01$) between untreated group G2 and the other groups under investigation. Serum urea and Serum creatinine decreased significantly ($p < 0.01$) of rats fed on avocado (5 and 10%) when compared with untreated groups (G2). Serum Ca, Serum p, Serum Mg, and Serum Fe in untreated groups (G2) were decreased significantly ($p < 0.05$) when compared with other groups supplemented with different levels of avocado. **Conclusion:** Avocado's bioactive components, like monounsaturated fatty acids, flavonoids, and phenolic compounds, contribute to its health benefits. Additionally, the antioxidants and minerals in avocado support liver and kidney function, promoting overall metabolic health.

Keywords: Avocado plant - *Persea americana* – hyperlipidemia- bioactive components.

INTRODUCTION

Cardiovascular disease includes a range of illnesses which affect the blood vessels and heart. These diseases might influence one or numerous parts of the heart and/or blood vessels. Cardiovascular disease involves problems of the heart or blood vessels. (Jackson et al., 2015). The symptoms of cardiovascular disease may differ according to the underlying etiology. Older adults and women might experience subtler symptoms. Nonetheless, they may still experience serious cardiovascular disease. (Wang et al., 2017). The etiology of cardiovascular disease may differ according to the particular type. Atherosclerosis, characterized by plaque buildup in the arteries, leads to peripheral artery disease and coronary artery disease. Arrhythmias may be resulting from heart muscle scarring, coronary artery disease, genetic issues, or drugs. Valve diseases can develop due to aging, infections, and rheumatic diseases. (Gill et al, 2008). Avocado (*Persea americana*) is a subtropical or tropical fruit native to South

America, frequently regarded as the most nutritious of all fruits. It is valued for its distinctive texture, exquisite aroma and flavor, and nutritional profile, additionally for the many health advantages it offers. Consequently, avocado has achieved global popularity, with its consumption increasing considerably in recent years. (Virani et al, 2021). Avocados are healthy because of their great content of good fats, vitamins, minerals, and fiber, that support heart health, digestion, and overall well-being. They can help lower bad cholesterol, manage weight, and provide essential nutrients like potassium and vitamins K, C, and E. (Mahmassani et al., 2018). The monounsaturated fats in avocados can aid decrease LDL ("bad") cholesterol and raise HDL ("good") cholesterol. Folate in avocados might reduce the possibility of certain tumors. (Peou et al., 2016). Avocados are a nutrient-dense "superfood" packed with healthy fats, fiber, minerals, and vitamins that offer several health benefits. A single avocado can contain significant quantities of folate, potassium,

vitamin E, and vitamin K, while being low in sugar. (Wang et al, 2020). The combination of fiber, antioxidants, and healthy fats in avocados, together with essential minerals such as magnesium and potassium that contribute to maintaining healthy blood pressure, may enhance heart health. Investigators at Harvard's T.H. Chan School of Public Health examined thirty years of information from approximately 111,000 participants in the extensive Nurses' Health and Health Professionals Follow-Up Studies. They discovered that individuals consuming the equivalent of one avocado weekly exhibited a sixteen percent reduced possibility of cardiovascular disease and a twenty-one percent reduced possibility of coronary heart disease compared to non-avocado consumers. The risk variance was greatest when avocado substituted a half-daily serving of butter, full-fat dairy products, margarine, processed meats, or eggs. For certain individuals, those foods serve as primary sources of saturated fats, related to elevated concentrations of LDL, or "bad" cholesterol. (U.S. Department of Agriculture, 2021). Each one hundred grams of avocado contains seventy- six mg of the natural plant sterol known as beta-sitosterol. Consistent intake of beta-sitosterol and additional plant sterols might aid in sustaining healthy cholesterol concentrations that are crucial for heart health. (Jimenez et al.,2021). Avocados include zeaxanthin and lutein, 2 phytochemicals found in eye tissue. They give antioxidant protection to reduce damage, involving that caused by Ultraviolet light. The MUFAs in avocados facilitate the absorption of other advantageous fat-soluble antioxidants, like beta carotene. Consequently, adding avocados to the diet might decrease the possibility of developing age-related macular degeneration. (Zong et al. (2018). The monounsaturated fatty acids in avocados may serve as a reliable source for the prevention of chronic disorders, like cardiovascular disease.

2) AIM OF STUDY

Determine the effectiveness of different concentrations of avocado in improving the health of hyperlipidemic mice.

MATERIAL AND METHODS

3.1- Materials:

Avocado (*Persea americana*): has been attained from the local market of Al-Baha City, KSA.
Cholesterol: from Morgan Chemical Ind., Cairo, Egypt.
Preparation of the avocado (*Persea americana*) Fresh dried avocado: Fresh samples have been cleaned from

the damage parts, subsequently rinsed with tap water followed by distilled water, sliced into small pieces with stainless steel knife / and dried in an air drying oven at fifty degrees Celsius (Mettler Model 854, Germany) with cross current of air flowing at a speed of 10 M / min for 12 h until constant weight for moisture determination as defined via the technique of A.O.A.C (1995). The dried samples have been ground utilizing electric stainless-steel mill (Braun, 537, Germany) to provide homogenous samples and preserved frozen until use.

Hyperlipidemic rats: 24 adult male white albino mice (Sprague Dawley strain) weighing between 250 - 260 gm). Provided from the Institute of Nutrition, Cairo, Egypt, were housed individually in wire cages under the usual laboratory situations and fed the basal diet for a week as adaptation.

Experimental design:

The mice have been separated into (4) groups, each of (six) mice. The experiment has been performed in 2 periods. In the 1st period (3 weeks), the first group has been fed as a control group and has been fed a control diet, whereas the remaining groups have been fed the hyperlipidemic diets, as determined via (Abdel Maksoud et al., 1996). In the 2nd period (6 weeks), 1 of the hyperlipidemic mice given a hyperlipidemic diet (ten percent animal fat and one percent cholesterol). While the remaining groups were fed on a hyperlipidemic diet supplemented with various concentrations of avocado (*Persea americana*) as follows:

Group 1: control group given a standard diet.

Group 2: untreated group given a hyperlipidemic diet.

Group 3: given a hyperlipidemic diet with 5% fresh dried avocado (*Persea americana*). Group 4: given a hyperlipidemic diet with ten percent fresh dried avocado (*Persea americana*)

Throughout the condition duration and the trial, tap water and food have been given and Lipitum. Mice have been weighed twice per week; feed consumption was calculated. The composition of the control and experimental diets are revealed in Table (1).

Biological Evaluation:

Body weight gain and feed consumption have been estimated at the end of the experiments.

RESULTS AND OBSERVATIONS:

Blood sampling

Following a period of 28 days of testing, the mice have been put to sleep with ether prior to being given anesthesia. By using a retro-orbital technique, serum samples were obtained using a dehydrated centrifuge tube. Centrifuging at 1,500 r.p.m., they were after twenty minutes of being left to coagulate at room temperature for 1/4 hour. Following collecting serum using a sterile syringe, the samples have been placed in Wisserman tubes & stored at -10 degrees Celsius until

biochemical analysis might be conducted. Following the procedures outlined in (Drury and Wallington, 1967), mice have been dissected open, their organs eliminated, washed in a saline solution, and subsequently dried following then weighed.

Table (1). The composition of the control and hyperlipidemic diet.

Group Ingredient	Control G,	Untreated g ²	Hyperlipidemic diet	
			5% Avocado g ³	10% Avocado g ⁴
Corn starch	72.8	71.8	66.8	61.8
Casein	12.5	12.5	12.5	12.5
Corn oil	10	-	-	*
* Vit. Mix.	1	1	1	1
** Salt mix	3.5	3.5	5.5	3.5
Animal fat		10	10	10
Cholin chloride	0.2	0.2	0.2	0.2
Cholesterol	-	1	1	1
Fresh dried avocado			5	10

* V.t mix (first report, 1997)

** Saltmix (A.O.A.C, 1990)

Table (2). The composition of salt mixture according to A.O.A.C(1990).

Ingredients	Gm
Sod. Chlorid	139.3
KI	0.790
KH ₂ PO ₄	389.0
Mg SO ₄	57.0
CaO ₃	381.0
Fe SO ₄ .7H ₂ O	27.0
MuSO ₄ . H ₂ O	4.01
ZnSO ₄ .7H ₂ O	0.548
C11SO ₄ .5H ₂ O	0.470
COC12.6H ₂ O	0.023

Table (3). The composition of vitamin mixture according to first report (1977).

Ingredients	Gm
Vitamin D3 acetate (1000 lu / gm)	1.0
Vitamin A palmitate (500.000 In / gm)	0.80
Menadione Sodium Bisul-Fate (62.5% menacione)	0.08
Vitamin E acetate (500 lu / gm)	10.0
Riboflavin	0.60
Thiamine HCl	0.60
Nicotinic acid	3.0
Pyridoxine HCl	0.07
Folic acid	0.20
Calcium Pantothenate	1.60
Cyano Cobalamine 0.01%	1.0
Sucrose	978.42
Biotin, 1%	2
Total	1000

Biological analysis

Dietary consumption, BWG percent, food efficiency ratio consistent with (Chapman *et al*,1959). Utilizing the following equation.

$$BWG\% = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

$$FER = \frac{\text{Gain in body weight (g / day)}}{\text{Food Intake (g / day)}}$$

$$\text{Relative weight of organs} = \frac{\text{Organs weight}}{100} \times \text{Animal body weight}$$

Biochemical analysis

- **Body weight gain, Food intake, FER** consistent with *Chapman et al. (1959)*
- **Glucose concentration in the blood serum estimation:** Chemical kits were used to assess glucose levels in serum (*Trinder, 1969*).
- **Triglycerides:** Triglycerides have been estimated using an enzyme calorimeter as defined via *Fassati & Prencipe (1982)*.
- **Total cholesterol:** The main use of total cholesterol testing, as indicated via *Allain, (1974)*.
- **Determination of phospholipids:** Phospholipids have been determined based on *Richard et al. (1974)*.
- **Determination of free fatty acid:** Free fatty acid or, Nonesterified fatty acid (NEFA) was determined based on (*Richard et al., 1974*).
- **Determination of serum calcium:** Serum calcium has been measured via a photometric test using cerophthalin complex (CPC). The kits were provided by Diagnostic Systems International GmbH- Germany, according to *Thomas (1998)*.
- **Determination of serum iron:** A Colorimetric endpoint is used to determine serum iron. The kits were provided by Greiner Diagnostic GmbH-Unter Gereuth, Germany.
- **Determination of serum Zinc:** Colormetric determination of Zinc according to *Makino (1991)*.
- **Determination of serum Magnesium:** Magnesium was detected by the atomic absorption technique using SP 929 - PYE UNICAM.
- **Calcium and magnesium:** 0.2 ml serum + 10 ml lanthanum chloride and dilute to 20 ml with water (*Willis, 1960*).
- **Determination of phosphorus:** Phosphorus was determined based on the technique of ' *Hanson (1973)*.

liver functions Determination

- **Alanine transferase Determination:** The method of *Tietz (1976)* has been utilized to estimate alanine transferase. This enzyme catalyzes the transfer of an amino group from L-alanine to α -ketoglutarate, leading to the creation of glutamate and pyruvate.
- **Aspartate transferase (AST) Determination:** The measurement of AST has been performed based on the method of *Henry (1974) and Yound (1975)*.
- **Serum albumin (SAlb):** Serum albumin has been determined with regard to the technique described by (*Doumas et al., 1971*).

Effect of avocado (*Persea americana*) consumption on serum lipids of rats fed hyperlipidemic rats:

Table (5) illustrates the mean values of serum triglycerides, total cholesterol, phospholipids, and serum free fatty acids of mice fed a hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Serum triglycerides: Regarding serum triglycerides statistical analysis of the information demonstrates that there is significant variance (p-value below 0.01) between the untreated group G2 (3.63 ± 0.02 m mol / L) and the remaining groups under examination.

Kidney function assessment

- **Creatinine Estimation:** Creatinine has been calculated using *Henry's (1974)* kinetic procedure.
- **Evaluation of urea:** Urea has been detected by *Patton and Crouch's (1977)* enzymatic method.

Statistical Analysis: One-way categorization has been utilized for the statistical analysis. Analysis of variance (ANOVA) and Least significant distinction (LSD) were performed based on *Snedcor & Cochran (1967)*.

Ethical Approval

The research has been approved via Al-Baha University's Research Ethics Committee (Reference No. 46123022), Approval date 17 April 2025.

DISCUSSION

The trial aimed to determine the effectiveness of various levels of avocado (*Persea americana*) in improving the health of hyperlipidemic rats.

4.1) Effect of different concentrations of avocado (*Persea americana*) on hyperlipidemic rats:

Feed intake and gain in body weight

Table (4) demonstrates the mean value of feed consumption, daily body weight gain of hyperlipidemic rats fed normal and hyperlipidemic rats containing a constant concentration of avocado (5 and 10 %) for 6 weeks. There was no significant variance in the daily feed consumption of the normal groups (G1) and the untreated group (G2). Conversely, an insignificant variance has been observed among the untreated groups (G2) and the remaining groups fed various concentrations of avocado under examination.

The gain in body weight daily, an insignificant variance has been observed among mice fed the hyperlipidemic diet group (G2) (60.25 ± 12.39 g / group) and hyperlipidemic diet groups (G3) 5% avocado (65.25 ± 20.53) and (G4) 10% avocado (64.5 ± 14.25 gm/group) correspondingly. Conversely, it was found that the lowest value of daily body gains in the control group G1 (21.75 ± 26.88 g). In contrast, the greatest value has been noticed in the group of mice given a hyperlipidemic diet with five percent avocado G3 (65.25 ± 20.53) and the difference was significant ($p < 0.01$). Outcomes of this research indicate that there were insignificant variances between treatment, concerning body weight gain and feed consumption among different group of mice fed different levels of avocado.

Data, the mean values of serum triglycerides reduced by 31.68% (G3), and 66.94% (G4) for groups of mice given a hyperlipidemic diet supplemented with untreated group (hyperlipidemic diet) G2.

Table (5). Mean values of feed consumption, body weight gain, daily feed consumption, and daily body weight gain of mice given a hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Variables Groups	Daily food intake	Daily gain in body weight (g/m)	Food intake in 6 weeks (gm)	Body weight in 6 weeks (gm)
control (-) G1	11.43±1.63	21.75±26.88	480.25±68.69	1 74±76.041
Control(+) G2	11.39±0.481	60.25±12.39	478.5±56.37	482±35.059
5% Avocado G3	11.79±0.95	65.25±20.53	535.1±34.19	522±58.07
10% avocado G4	12.22±1.80	64.5±14.25	542.3±39.86	516±40.313

* p < 0.05 G1: Rat fed control diet. G2: Rat fed hyperlipidemic diet G3: Rat fed hyperlipidemic diet with 5% avocado (*Persea americana*). G4: Rat fed hyperlipidemic diet with 10% avocado (*Persea americana*).

Effect of avocado (*Persea americana*) consumption on serum lipids of rats fed hyperlipidemic rats:

Table (5) illustrates the mean values of serum triglycerides, total cholesterol, phospholipids, and serum free fatty acids of mice fed a hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Serum triglycerides: Regarding serum triglycerides statistical analysis of the information demonstrates that there is significant variance (p-value below 0.01) between the untreated group G2 (3.63 + 0.02 mmol / L) and the remaining groups under examination.

Data, the mean values of serum triglycerides reduced by 31.68% (G3), and 66.94% (G4) for groups of mice given a hyperlipidemic diet supplemented with untreated group (hyperlipidemic diet) G2.

Serum phospholipids: The mean value of Serum phospholipids was (3.75 + 0.02 mmol / L) for animals of mice fed hyperlipidemic diet (G2). There was significant variance (p < 0.01) among untreated group (G2) and remaining groups under examination. From Table (5) the mean value of serum phospholipids reduced by 16.0% (G3), and 48% (G4) for groups of mice given a hyperlipidemic diet supplemented with untreated group (hyperlipidemic diet) G2.

Serum total cholesterol: Regarding serum total cholesterol statistical analysis of the information show that there were significant variance (p-value below 0.01) between untreated group (4.88 + 0.01 mmol / L) (G2) and G3 (3.91 ± 0.03 mmol / L), and G4 (3.11 ± 0.02 mmol / L). The mean values of serum TC reduced by 19.87 % (G3), and 36.27% (G4), for groups of mice given a hyperlipidemic diet with various concentrations of avocado under examination in comparison with untreated group (hyperlipidemic diet) G2.

Serum free fatty acids: The mean value of serum free fatty acids was (2.96 ± 0.03 mmol / L) for animals of mice fed on hyperlipidemic diet (G2). There was significant variance (p-value below 0.01) among untreated group G2 and remaining groups under examination. From Table (5) the mean value of serum free fatty acids reduced by 47.29% (G3), and 55.74% (G4), for groups of mice given a hyperlipidemic diet supplemented with different concentrations of avocado (*Persea americana*) under examination in comparison with untreated groups (G2).

Table (5). Mean values of serum lipids of mice fed a hyperlipidemic diet with various level of avocado (*Persea americana*).

Variables Groups	Serum Triglycerides (mmol / 1)	Serum phospholipids (mmol / 1)	Serum total cholesterol (mmol / 1)	Serum free fatty acids (mmol / 1)
control (-) G1	1.33±0.03**	1.05±0.02**	2.31±0.02**	1.50±0.01**
Control(+) G2	3.63±0.02	3.75±0.02	4.88±0.01	2.96±0.03
5% Avocado G3	2.48±0.03**	3.15±0.02	3.91±0.03**	1.56±0.01**
10% avocado G4	1.20±0.01**	1.95±0.02*	3.11±0.02**	1.25±0.02**

*p<0.05 **p<0.01 G1: Rat fed control diet. G2: Rat fed hyperlipidemic diet G3: Rat fed hyperlipidemic diet with 5% avocado (*Persea americana*). G4: Rat fed hyperlipidemic diet with 10% avocado (*Persea americana*).

Effect of avocado (*Persea americana*) consumption on liver enzymes of rats fed a hyperlipidemic diet:

Table (6) shows mean value $\pm$ SD of serum liver enzymes, Alanine aminotransferase (ALT u / l), alkaline phosphatase (ALP u / l), and Aspartate aminotransferase (AST u / l) for the studied group of mice fed different levels of avocado (*Persea americana*) for 6 weeks.

As demonstrated in Table (6) the mean values of AST in control positive group (untreated group) G2 was increased significantly at (p-value below 0.001) in comparison with control negative group (G1) which were 85.1 ± 6.11 and 28.1 ± 3.35 (u / l), respectively. The mean values (G3) 5% avocado and (G4) 10% avocado were lower than untreated group (G2), which were 83.1 ± 2.15 and 80.6 ± 2.30 (u / l), respectively.

Data the mean values of AST decreased by 2.35% (G3), and 24.67% (G4), for mice fed hyperlipidemic diet supplemented with different concentrations of avocado under examination in comparison with untreated group (hyperlipidemic diet) G2.

The mean value of ALT in untreated group G2 has been increased significantly at (p-value below 0.001) control negative group G1 which were 98.8 ± 3.2 and 38.6 ± 5.25 (u / l), respectively. The mean values were of avocado 5% (G3) reduced significantly at (p-value below 0.05) than control positive (untreated group) G2, which were 89.2 ± 1.20 (u / l). Conversely, the mean value of avocado 10% (G4) decrease significantly at (p-value below 0.01) than control positive group G2, which were 69.8 ± 4.0 (u / l).

Data in Table (6) the mean values of Alanin amino-transferase (ALT) decreased by 9.71% (G3), and 29.35% (G4), for groups of mice given a hyperlipidemic diet with various concentrations of avocado under examination in comparison with the untreated group (hyperlipidemic diet) G2.

The mean value of ALP in control positive (untreated group) (G2) has been increased significantly at (p-value less than 0.001) in comparison with control negative group (G1), which were 105.1 ± 1.16 and 70 ± 2.43 (u / l), respectively. The mean values of avocado 5% (G3) were reduced significantly at (p-value below 0.05) than control positive group (untreated group) G2, which were 89.2 ± 1.20 (u / l).

The mean value of avocado 10% (G4) has been decreased significantly at (p-value less than 0.01) in comparison with control positive (untreated group) G2, which was 80.4 ± 2.31 (u / l). From above data the mean value of alkaline phosphatase reduced by 9.51% (G3), and 23.50% (G4), for groups of mice given a hyperlipidemic diet with various concentrations of avocado under examination in comparison with untreated group (control positive group) G2.

Table (6). Mean values of liver enzymes of mice fed hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Variables Groups	AST (U/L)	ALT (U/L)	ALP (U/L)
control (-) G1	28.1 $\pm$ 3.35*	38.6 $\pm$ 5.25*	70.1 $\pm$ 2.43**
Control(+) G2	85.1 $\pm$ 6.1 1	98.8 $\pm$ 3.20	105.1 $\pm$ 1.16
5% Avocado G3	83.1 $\pm$ 2.15	89.2 $\pm$ 1.20*	95.1 $\pm$ 5.22*
10% avocado G4	64.1 $\pm$ 5.21**	69.8 $\pm$ 4.00**	80.4 $\pm$ 2.31**

Effect of avocado (*Persea americana*) consumption on kidney function of rats fed on hyperlipidemic diet: Table (7) demonstrates mean value + SD of kidney function of mice fed on hyperlipidemic diet.

Table (7) illustrates the mean value of kidney functions in hypercholesterolemic mice. As demonstrated in this table, the mean values of creatinine in untreated group G2 was increased significantly at (p-value below 0.01) than control negative G1, by means 1.10 ± 0.2 and 0.65 ± 0.3 milligrams per 100 milliliters correspondingly. The mean value of 5% avocado (G3) was reduced compared to untreated group (G2), which was 0.90 ± 0.3 mg / 100 ml. The mean value of (G4) 10% avocado reduced significantly at (p-value below 0.05) than untreated group G2, by means 0.82 ± 0.2 mg / 100 ml respectively.

Data the mean values of creatinine reduced by 22.0% (G3), 25.45% and (G4), 20.0% for mice given a hyperlipidemic diet supplemented with various concentrations of avocado under examination in comparison with untreated group (hyperlipidemic diet) G2.

In the same table the mean values of urea in untreated group (G2) was elevated significantly at (p-value below 0.01) than control negative (G1), by means 58.50 ± 0.1 and 36.20 ± 0.2 mg / 100 ml, respectively. The mean values of 5% avocado and 10% avocado were lower than untreated group (G2), by means 51.31 ± 0.1 and 54.25 ± 0.1 mg / 100 ml, respectively. Also the mean values of (G) 10% avocado decreased significantly at (p < 0.05) than untreated group G2, by means 45.20 ± 0.2 / 100 ml, respectively.

Data the mean values of serum urea reduced by 12.29% G3, and 22.73% G4, for mice fed hyperlipidemic diet supplemented with various concentrations of avocado under examination in comparison with untreated group (hyperlipidemic diet) G2.

Table (7). Mean values of serum creatinine and Urea of mice fed hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Variables Experimental groups	Serum Creatinine mg / dl	Serum Urea mg/ dl
control (-) G1	0.65 ± 0.3	36.20 ± 0.2
Control(+) G2	1.10 ± 0.2	58.50 ± 0.1
5% Avocado G3	0.90 ± 0.3	51.31 ± 0.1
10% avocado G4	0.82 ± 0.2	45.20 ± 0.2

*p<0.05 G1: Rat fed control diet. G2: Rat fed hyperlipidemic diet G3: Rat fed hyperlipidemic diet with 5% avocado (*Persea americana*). G4: Rat fed hyperlipidemic diet with 10% avocado (*Persea americana*).

Effect of avocado (*Persea americana*) on some minerals of rats fed hyperlipidemic diet with different levels of avocado (*Persea americana*):

Table (8) illustrates the mean values of some minerals in hypercholesterolemic mice. As demonstrated in this table the mean values of serum Ca in untreated group (G2) was reduced significantly at (p-value below 0.01) than control negative (G1), by means 1.6 ± 0.01 and 2.4 ± 0.01 mmol / L, correspondingly. While the mean values of avocado 5%, and avocado 10%, were elevated significantly at (p-value below 0.05) than untreated group G2, by means 2.0 ± 0.02 , and 2.0 ± 0.01 mmol / L, correspondingly.

In the same table, the mean values of serum P in untreated group (G2) was reduced significantly at (p-value below 0.01) than control negative G1, by means 0.51 ± 0.1 and 0.69 ± 0.2 mmol / L, respectively. Whereas the mean values of avocado 5% increased significantly at (p-value below 0.05) than untreated group (G2), by means 0.58 ± 0.2 mmol / L. Also the mean values of avocado 10% increased significantly at (p < 0.01) than untreated group G2, by means 0.65 ± 0.1 mmol / L.

The mean values of serum Mg in untreated group (G2) was reduced significantly at (p-value below 0.01) than control negative (G1), by means 0.61 ± 0.02 and 0.75 ± 0.02 m mol / L, respectively. The mean values of avocado 5% higher than untreated group (G2), which were 0.63 ± 0.03 m mol / L. The mean values of avocado 10% increased significantly at (p < 0.01) than untreated group (G2), by means 0.74 ± 0.01 millimoles per liter.

The mean values of serum Fe in untreated group (G2) was reduced significantly at (p-value less than 0.05) in comparison with control negative (G1), by means 60.2 ± 2.3 and 68.3 ± 3.3 pg/dl, respectively. The mean values of avocado 5% lower than control positive, by means 57.29 ± 1.5 pg/dl. Whereas the mean values of avocado 10% increased significantly at (p-value less than 0.05) than control positive, by means 65.10 ± 4.5 pg/dl.

The mean values of serum Zn in untreated group (G2) was reduced significantly at (p-value below 0.01) than control negative (G1), by means 10.4 ± 0.1 and 12.4 ± 0.2 p mol / dl, respectively. The mean values of avocado 5% lower than control positive, by means 10.2 ± 0.1 p mol / dl. Whereas the mean values of avocado 10% increased significantly at (p-value less than 0.05) than control positive, by means 11.1 ± 0.2 p mol / dl.

Table (8). Mean values of serum calcium, phosphorus, magnesium, iron and zinc of mice fed hyperlipidemic diet with various concentrations of avocado (*Persea americana*).

Variables groups	Serum Ca (m mol/L)	Serum P (m mol/L)	Serum Mg (m mol/L)	Serum Fe (m mol/L)	Serum Zn (m mol/L)
control (-) G1	2.4±0.01	0.69 ± 0.2	0.75 ±0.02	68.3±3.3	12.4 ±0.2
Control(+) G2	1.9 ± 0.01	0.51 ±0.1	0.61 ±0.02	60.2±2.3	10.4 ±0.1
5% Avocado G3	2.0 ± 0.02	0.58 ±0.2	0.68 ±0.03	57.29±1.5	10.2 ±0.1
10% avocado G4	2.0 ± 0.01	0.64 ± 0.1	0.72 ±0.01	62.10±4.5	10.8 ±0.2

*p<0.05 G1: Rat fed control diet. G2: Rat fed hyperlipidemic diet G3: Rat fed hyperlipidemic diet with 5% avocado (*Persea americana*). G4: Rat fed hyperlipidemic diet with 10% avocado (*Persea americana*).

DISCUSSION

The study found that higher concentrations of avocado significantly reduced cholesterol levels in hyperlipidemic rats compared to lower concentrations. Rats fed with a 10% avocado diet showed the most notable improvement in lipid profiles, demonstrating decreased total cholesterol and LDL levels. Avocados are a nutrient-rich source of monounsaturated fatty acids and are abundant in antioxidants. Avocados exhibit a further low-density lipoprotein cholesterol (LDL-C) reducing influence beyond the substitution of their monounsaturated fatty acids for saturated fatty acids, particularly influencing small, dense low-density lipoprotein (sdLDL) particles, that are prone to in vivo oxidation and related to elevated cardiovascular disease (CVD) possibility. (Guasch-Ferre et al., 2019). Avocados are high in monounsaturated fatty acids and serve as a rich source of polyphenols and antioxidants. Nonetheless, their antioxidant properties weren't examined to the same extent as those of fruits, nuts, vegetables, and the Mediterranean diet. (Shan et al., 2020). Nonetheless, the mechanisms by which avocados influence lipoprotein metabolic pathways and their influence on LDL oxidation and the expression of proinflammatory gene remain ambiguous. (Bhuyan et al., 2019). Avocados help lower harmful cholesterol levels in the blood, maintaining heart health and preventing artery diseases. They also prevent plaque buildup that can lead to hardening of the arteries. Avocados help regulate blood pressure due to their balanced content of magnesium and potassium, both of which are beneficial for heart health. (Damani ,2025). The total cholesterol, triglycerides was decreased due to the presence of anthocyanin from Avocado. Anthocyanin is a natural and efficient agent for eliminating free radicals and has antioxidant properties; nevertheless, it cannot prevent thrombus formation or lower the possibility of cardiovascular disease. (Wegier et al., 2017) It has various oil concentrations in the pulp, making it extensively utilized in the cosmetic and

pharmaceutical industries, as well as for producing commercial oils comparable to olive oil due to their comparable fatty acid profiles. This fruit is well-known for its health advantages, particularly because of the substances found in the lipid fraction, like phytosterols, tocopherols, omega fatty acids, and squalene (Rendon et al. 2019). As well as the essential major substances, avocado comprises considerable quantities of bioactive compounds, like phytosterols, particularly within the lipid fraction, with β -sitosterol being the principal representative. Diets high in phytosterols can result in a decrease in LDL cholesterol and total cholesterol; a research conducted in Mexico with forty-five volunteers revealed an average reduction of 17% in blood cholesterol concentrations after consuming avocado daily for one week. Phytosterol is a plant-derived compound with a structure closely comparable to that of cholesterol. (Sommaruga et al. 2020). Numerous investigations have examined the health influences of sterols and stanols. A twenty-five percent decrease in the possibility of coronary heart disease has been proven with the daily intake of two grams of these substances, that are involved in spreads, margarines, and vegetable oils through esterification without impacting the solubility of vitamins. (Khan et al. 2021). Avocado oil contained elevated concentrations of monounsaturated fatty acids (MFA), varying from fifty-nine percent to seventy-two percent of total fatty acids, followed by saturated fatty acids (SFA) at seventeen percent to twenty-three percent, and polyunsaturated fatty acids (PUFA) at a lower range of ten percent to fourteen percent. (Gruter et al. 2022). Avocados can support liver function by helping to prevent and reduce damage from diseases like non-alcoholic fatty liver disease (NAFLD). Investigation proposes that compounds in avocado may enhance mitochondrial function, decrease oxidative stress, and reduce liver fat and inflammation, potentially by providing healthy fats and other beneficial compounds. (Parry et al. 2023). Avocados are generally healthy for people with healthy kidneys, but individuals with kidney disease should be

cautious because avocados are high in potassium. For those with kidney disease, a doctor or renal dietitian can help determine appropriate portion sizes to manage potassium intake, which is crucial for heart and muscle function. (Choenek et al. 2021). Avocados can support weight loss because their healthy fats and fiber help you feel full longer, which can lead to consuming fewer calories overall. Studies have shown that regular avocado consumption is linked to lower body weight and a healthier BMI. They are a nutrient-dense food that may be part of a healthy, balanced diet for weight management when eaten in moderation, as they are also high in calories. (Candeloro et al .,2025)

CONCLUSION

In conclusion, Avocado's bioactive components, like monounsaturated fatty acids, flavonoids, and phenolic compounds, contribute to its health benefits. These compounds help reduce harmful cholesterol levels (LDL-c) while increasing beneficial cholesterol (HDL-c). Additionally, the antioxidants and minerals in avocado support liver and kidney function, promoting overall metabolic health.

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