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Effect of Sodium Alginate ,Propolise and Carob Seeds Powder on Hypercholosterolemic Albino Rats

Mona E. M.Naga

Home Economics Department, Faculty of Specific Education, Minufiya University, Egypt.

Abstract

This investigation was conducted to explore the protective effect of sodium alginate, propolis and carob seeds,for hypercholesterolemic and atherosclerotic rats. to improve the blood glucose level , the lipids profile Total triglycerides (TG) Total Cholesterol (TC),Atherogenic index(AI), Low density lipoprotein Cholesterol(LDL-c)-High density lipoprotein Cholesterol(HDL-c),Very low density lipoprotein Cholesterol (VLDL-c),and some other physiological characteristics such as the liver function Aspartate transaminas (AST),Alanine transaminase (ALT)and Alkaline phosphatase(ALP), kidneys functions (uric acid, urea nitrogen and creatinine) , in addition to the Body weight gain% (B.W.G), Food intake(FI) and weight of internal organs. Twenty five(25) male mature albino rats were used and divided into five main groups ,(5 rats each group), one of them used as control -ve while other groups had given 1.5% pure cholesterol plus 10% sheep tail fat for 15 days. One of these groups left as control+ve, and other groups each fedon sodium alginate , propolis and carob seeds powder , at doses of 500 mg /kg B. W. for 42 days. Such treatments lowered the TC, TG,

VLDL-c, LDL-c, & AI, while raised the HDL-c. Also, colloids diets reduced serum glucose, AST, ALT, ALP. The histopatholgical changes were; in line with the biochemical changes. Moreover, colloids treatment improved the Feed efficienncy ratio (FER). Therefore, the study recommends that the colloids can be used in the treatment of the hypercholesterolemia. The food, should tend to invent prouducts with colloids, specially the carob powder that easily (can be) added to baking goods .Similarly sodium alginate &propolis may be blended with foods.

Introduction

Atherosclerosis is a disease in which plaque builds up inside the arteries. Arteries are blood vessels that carry oxygen-rich blood to the heart and other parts of the body. Plaque is made up of fat, cholesterol, calcium, and other substances found in the blood. Over time, plaque hardens and narrows the arteries, reducing blood flow to the organs (such as the heart) and other parts of the body. This can lead to serious problems, including heart attack, stroke, or even death. ***Glance (2009)***.

Nader et al., (2010) found that hypercholesterolemic and cholesterol enriched diet resulted in development of atherosclerosis in new Zealand rabbits, propolis however lowered AI in rabbits.***Syed et al., (2016)*** mentioned that Carob kibble has substantial potential to be used as a food ingredient. This article focuses on the composition, health benefits, and food applications of carob kibble . reported by ***Fuliang et al., (2005),***it was reported that propolis collected from north China lowered TC, TG, LDL, VLDL, while raised HDL , lipids antioxidases and scavenged free radicals in rats with diabetes mellitus.***Fernandes et al., (2002)*** indicated that cholesterol

level in blood plasma of rabbits reduced when animals received ethanol propolis extract. ***Dennis (2003)*** reported that sodium alginate has a wide use across a wide variety of industries including food.

Accordingly, this work aimed to study the effect of that collides on hyperglycemia and atherosclerosis on albino rats.

Materials and Method

Materials:

Casein not sodium salt, all vitamins, minerals, cellulose, choline chloride, methionine, cholesterol were obtained from Morgan Company, Cairo, Egypt.Oil and corn starch were obtained from local market of Menoufia, Egypt.Colloids carob seeds powder **(Ceratonia siliqua),** sodium alginate and propolis,were purchased as dried material from the local market in Egypt.

Methods:

Preparation of colloid extract samples:

colloids(carob seed ,sodium alginate and propolis) were prepared as follow: Twenty (20g) grams of each collides + 1000 ml distilled water, were kept in conical flasks provided with glass condensers , then heated under reflux for one hour at 70°C. The heated mixture was cooled and filtered. The filtrate poured in different Petri dishes and dried in fan oven at 70°C till dryness as a film which was separated, then crushed and the dried powder solubilized in distilled water. Extracts were then kept in dark bottles to prevent oxidation and saved until the experiment . Each rat orally administrated with 1 ml of distilled water containing 750 mg /kg B.Wt.,of rat from collides.

Experminal diet:

The basal diet was prepared according to ***Reeves et al., (1993).***

Hypercholestrolemic Rats:

Healthy male albino rats were fed 1.5% pure cholesterol for 15days as well as 50% Fat Les sheep (sheep tail fat) according to the method described by ***Drury and Wallington (1967).***

Biological Experiment:

Twenty five (25) mature male albino rats, weighting between 180–200 g were use obtined from Research Institute of Ophthalmology, Egypt.Rats were housed in individual stainless steel cages, under controlled environmental conditions .Diets were introduced to rats in a special non scattering feeding cup to avoid loss of feed and contamination. Tap water was provided to rats by means of glass tubes projecting through wire cages from inverted bottles supported to one side of the cage. Feed and water provided and checked daily.

Expermintal desisn:

Grouping design and feeding of rats:

All groups (5rats each) were fed for 42 days .The animals were weighed twice weekly throughout the period of the experiment .

Group negative control: Fed on a besel diet only.

Group positive control: Fed on pure cholestero powder and sheep tail fat.

Group Hypercholesterolemic rats: Fed on Basel diet plus carob seeds Powder in water orally administrated, at a dose of 500mg/kg B.wt

Group Hypercholesterolemic rats: Fed on basel diet,plus sodium alginate in water orally administrated, at a dose of 500mg/kg B.w,t.

Group Hypercholesterolemic rats: Fed on basal diet, plus propolis in water orally administrated, at a dose of 500mg/kg B.wt..

Blood sampling collections:

At the end of experiment period, blood samples were collected after 12 hours fasting from the portal vein; the rats were sacrificed under ether anesthesia. Blood samples were received into clean dry centrifuge tubes and left to clot at room temperature, then centrifuged for 10 minutes at 3000 r.p.m to separate the serum. Serum was carefully aspirated and transferred into clean covettee tubes and stored frozen at -20°C for analysis ***(Malhotra, 2003).***

Biological evaluation:

Biological evaluation was carried out by determination of body weight gain% (BWG %) & feed efficiency ratio (FER) according to ***Chapman et al., (1959).***

Biochemical parameters:

Determination of serum glucose:

Serum glucose was measured using the modified kinetic method according to ***(Kaplan, 1984).***

Determination of serum lipids fractions:

Serum triglycerides (TG) were measured using the modified kinetic method according to the method described by ***Fossati and Principe (1982).***Total Serum cholesterol was measured using the modified kinetic method according to ***Richmond (1973).***Serum high density lipoprotein cholesterol (HDL-c) was measured using the modified kinetic method according to ***Allain (1974).*** Serum low density

lipoprotein cholesterol (LDL-c) was calculated as mg/dl according to ***Castelli et al., (1977)*** equation:

LDL Concentration mg/dl =Total Cholesterol- HDL -VLDL

Serum very low density lipoprotein cholesterol (VLDL-c) was calculated as mg/dl according to ***Lee and Nieman (1996)*** equation:

$$\text{VLDL-C concentration mg/dl} = \frac{\text{T.G}}{5}$$

Determination of alanine transaminase (ALT):

The activities were measured were in serum using the modified kinetic method of ***Tietz (1976)***.

Determination of aspartate transferase (AST):

The activities were measured in serum using the modified kinetic method of ***Henry (1974)***.

Determination of alkaline phosphatase (ALP):

The activities were measured in serum using the modified kinetic method or liquicolor of ***Moss (1982)***.

Determination of kidney function indicators:

Urea nitrogen was determined in serum using the modified kinetic method or liquicolor of ***Patton and Crouch (1977).***Serum creatinine was measured using the modified kinetic method according to ***Schirmeister (1964)***.Serum uric acid was measured using the modified kinetic method according to ***While et al., (1970)***.

Histopathological study:

Autopsy samples were taken from the internal organs (heart & aorta) of rats and fixed in 10% buffered formalin for twenty four hours. Washing was done in tap water, then serial dilutions of alcohol till

absolute ethyl, were used for dehydration. Specimens were cleared in xylene, embedded in paraffin at 56 degree in hot air oven for twenty four hours. Paraffin bees wax tissue blocks were prepared for sectioning at 4 microns thickness by sliding microtome. The obtained tissue sections were collected on glass slides, deparaffinized and stained by hematoxylin and eosin (Banchroft et al., 1996) for histopathological examinations by the light microscope.

Statistical analysis of data:

Data were statistically analyzed using a computerized program . for Duncan Multiple Range Test (one way ANOVA test) according to ***(Armitage and Berry, 1987)*.**

Results and Discussion

Biological parameters:

Effect of colloids on body weight gain (BWG),feed intake (FI) and feed efficiency ratio (FER) of hypercholesterolemic rats.

Data presented in table (1) show the effect of colloids (carob powder, sodium alginate and propolise) on hypercholesterolemic rats. It is evident that hypercholesterolemia increased the BWG and FI of rats which in control (-ve) were (35.00±5.00 and 23.70±1.60g) respectively, while for control (+ve) group were (45.00±3.00 and 48.80±2.60g) respectively. It is clear that hypercholesterolemia decreased the feed efficiency ratio (FER) of control (+ve) group which was (0.33±0.013). Colloids reversed that change of control (+ ve) rats leading to increased FER. While decrease of FI,BWG increase of FER recorded for the carob powder group. ***Koya et al., (2009)*** found that propolis extract administration to obese mouse resulted in correcting the body weight gain.

Shoab, H. (2014) who found that hypercholesterlemia raised BWG & FI while reduced FER; feeding of rats on diets containing phytogenic materials reversed these changes.

Biochemical parameters:

Serum glucose.

It could be cleared in table (2) that rats fed on hypercholesterolemic and high fat diet control (+ve) group showed significant increase in the serum level of glucose as compared to control(–ve) healthy group which were (137.4 ±2.20 and 61.2±1.20mg\dl) respectively. Rats of artheriosclerosis and orally administrated of sodium alginate , propolis showed significant decreases in serum glucose as compared to control positive group, and carob powder showed the highest decrease in serum glucose .

The result in table (2) were in line with that reported by ***Lisbona et al., (2013)*** found that propolis supplemention leads to lower glucose and cholesterol of senescent wister rats. ***McDougall et al., (2005)*** found that compounds in carob may be reducing the blood glucose response by inhibiting the enzyme activity (amylases) resulting in the slow rate of starch digestion. Carob flour, particularly carob fiber, being rich in polyphenols and tannins, has a high potential to be incorporated into diabetic-friendly foods.

Effect of collides on lipid profile :

Total cholesterol (TC) , triglyceride (TG) and atherogenic index (AI):

Data recorded in table (3) show the effect of oral administration of colloids sources on total cholesterol (TC)of hypercholesterolemic and atherosclerosis rats. Control (+ve) groups showed significant increase in total cholesterol as compared to

healthy rats(-ve). Rats of colloids treatments reversed the change occurring in control (+ve) rats leading to decreased TC and TG showing decreased of total cholesterol recorded for carob seeds group,whil the best of treatments numerically of the carob powder recording AI of (1.3± 0.40), because this group showed the highest decrease of atherogenic index with nonsignificant difference compared to that of propolise .

Khaled et al., (2015) revealed that feeding rats with 10 and 20 % carob powder improved lipid profile parameters and histopathological characteristics in the heart and kidney of experimental rats.

HDLc, LDLc & VLDLC.

It is evident in table (4) that rats fed on hypercholesterolemic and high fat diet control (+ve) group indicated significant decrease in HDL-c but significant increase in LDL-c and VLDL-c as compared to normal healthy rats .All rats of hypercholesterolemia and atherosclerosis, and orally administrated with 500 mg/kg .B.W.T of carob powder ,sodium alginate and propolis, showed significant increase in HDL-c but significant decrease in LDL-c and VLDL-c levels. Treatment of carob powder showed the highest increase in HDL-c but the highest decrease in LDL-c and VLDL-c compared to control (+ve) positive group . ***Shoab, H. (2014)*** same conclusion,was reported that with feeding of hypercholesterolemic rats on diets containing admixture of orange peels, pomegranate peals, parsley and celery corrected the changes of VLDL-c, LDL-c and HDL-c disorder compared to rats of hypercholesterolemia. ***Kimura et al., (1996)*** sugested that low molecular weight sodium alginate (Na AL) should be used as dietary fiber for the prevention of obesity,

hypercholesterolemia and diabetes mill mell itus. ***Ruiz-Roso et al., (2010)*** found that the consumption of fiber very rich in insoluble polyphenols shows beneficial effects on human blood lipid profile and may be effective in prevention and treatment of hyperglycemia**.**

As reported that by ***Fuliang et al., (2005),*** propolis collected from north China lowered TC, TG, LDL, VLDL, while raised HDL , lipids antioxidases and scavenged free radicals in rats with diabetes mellitus.

Effect of collides on total protein (TP) and total bilirubin (T.Bil.) of hypercholesterolemic and atherosclerosis rats

Data recorded in table (5) reflect the effect of treatments of hypercholesterolemic and atherosclerosis rats with carob powder, sodium alginate and propolis, on serum total protein of control (+ve) group. The results donated that there was significant increase of (TP) and (T.Bil.) in infected control (-ve) for control (+ve) rats. All rats administrated with all colloids showed significant increases in total protein (TP) as compared to control (+ve) grou, but showed significant decreases in (T.Bil.) . It is evident that the best treatment was that of carob powder and propolis, with nonsignificant difference between them .Whil The best of treatment was carob powder recorded (T.Bil.)of (0.25± 0.04 mg\dl) because this group caused lowest (T.Bil.) compared to rats. ***Badr et al., (2011)*** found that Egyptian propolis could protect from the dysfunction of liver based on lowering AST &ALT activities , raising levels of Total. proteins ,albumins &globulin .

Effect of collides on liver function .

AST, ALT and ALP:

It could be cleared in table (6) that rats fed on hypercholesterolemic diet control (+ve) group showed significant increases in liver enzyme activities (AST-ALT and ALP) as compared to healthy rats control (–ve). All rats of administrated with all colloids showed significant decreases in liver enzymes and (AST, ALT and ALP) when compared to control (+ve) group.The highest sodium Alginate significant decrease recorded for (AST-ALT) as compared to control (+ve group).

These results could be agree with observed that rats orally fed with carob powder was the best treatment showing ALP activity of (142.3±2.50)U /L when compared to control (+ve) group. ***El-Mahdy (2015)*** who found significant decrease of ALP when hypercholesterolimic rats fed on carob Powder diet.

Zhu et al., (2011) suggested that propolis maprevent hepatorenal injury in rats, and caused measurable decrease in AST&ALT of liver injury rats.

Effect of collids on kidneys function.

Ceraetinine, urea, uric acid:

It is clear from table (7) results that rats fed on hypercholesterolemic diet control(+ve) group showed a significant increase in kidneys function parameters (creatinine , urea and uric acid) which were (0.5± 0.10, 36.5±3.70) and (3.62±1.09) respectively, while values were (0.32±0.01 ,21.1±2.5 and 1.36 ±0.94mg\dl) respectively,in normal rats. Rats of hypercholestrolemia and orally administrated with 500 ml / kg b.W.t.) sodium alginate,

propolis and carob powder showed significant decrease in kidneys functions (certainine, urea and uric acid) when compared to control positive groups. Rats of hypercholestrolemia and orally administrated with carob powder showed the highest decrease in kidney functions parameters (creatinine , urea , and uric Acid) when compared to control positive group. Similar results reported by ***Sherif. N., (2015). Bader et al., (2011)*** found that Egyption propolis could protect rats from kidneys dysfunction mic based on lowering creatinine level. ***Khalil et al., (2010)*** reported that propolis decreased urea and creatinine in serum of rabbits.

Histopathological results:

The Histopathological structure of the internal organs (heart& aorta) revealed pronounced changes due to hyperclosterolemia, While feeding on diets containing the tested extracts powders of the carob seeds ,sodium alginate and propolis groups (photos, 1,2,3,4……10)reversed these changes .This was in line with the histological &biochemical changes table (1:7).

Histopathologically , ***Nader et al .,(2010)***found that atherosclerosis of high –cholesterol rats resulted in endothelial damage and thickened foam cells ,while propolis provided motecrion against such damage ***Hassanein et al., (2015)*** mentioned that the carob pulp powder has been recommended in the regimen of obese /overweight, hyperlipidemic and/or hypercholesterolemic diets due to its beneficial effects in the blood lipid profile and histopathology of the heart and kidney**.**

Table (1): Effect of oral administration of collids on body weight gain (BWG %), feed intake (FI) and feed efficiency ratio (FER) of hypercholesterolemic rats .

Colloids / Groups	BWG (g/42day) Mean ± SD	FI (g/day) Mean ± SD	FER Mean ± SD
Control (-)	35.00±5.00c	23.70±1.60 c	0.035±3.125a
Contro (+)	45.00±3.00a	48.80±2.60a	0.021±0.027a
Carob seeds	30.00±1.00d	17.00±2.00d	0.042±0.012a
Sodium alginate	33.00±2.00b	21.50±2.30c	0.036±0.020a
Propolis	39.00±2.00b	30.20±1.10b	0.030±.0.04a

Means with Values denote arithmetic means ± Standard deviation of the mean. Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05.

Table (2): Effec of oral administration of colloids matrials on serum glucose levels of hypercholesterolemic rats

Colloids / Groups	Serum of glucose (mg/dl) Mean ± SD
Control (-)	61±1.20b
Contro (+)	137.4±2.20a
Carob seeds	46.1±1.30d
Sodium alginate	61.3±0.40b
Propolis	50.1±13.00c

Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05 .

Table (3): Effect of oral administration of colloids on total cholesterol (Tc) and triglyceride (TG) of hypercholesterolemic rats

Colloids / Groups	TC(mg/dl) Mean ± SD	TG(mg/dl) Mean ± SD	Al(mg/dl) Mean ± SD
Control (-)	68±2.00c	50±1.00c	0.7±0.20b
Contro (+)	420±4.00a	217±2.00a	7.8±1.60a
Carob seeds	72±3.00bc	55±3.00bc	1.3±0.40b
Sodium alginate	75±1.00bc	57±2.00bc	1.7±0.50b
Propolis	80±2.00b	62±3.00b	1.1±0.20b

Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05.

Table (4): Effect of oral administratn of colloids on the serum levels of lipoproteins fractions (HDL-c- LDL-c and VLDL-c) of hypercholesterolemic rats

Colloids / Groups	HDLc(mg/dl Mean ± SD	LDLc(mg/dl) Mean ± SD	VLDLC(mg/dl Mean ± SD
Control (-)	40±2.00a	18±1.00d	10±2.00b
Contro (+)	25±3.00d	171.6±2.20a	10±2.00b
Carob seeds	35±3.00b	26±2.00c	23.4±2.30a
Sodium alginate	33±2.00bc	28.34±1.10c	13.66±1.10b
Propolis	30±2.00bc	37.2±1.10b	12.6±2.20b

Values denote arithmetic means ± Standard deviation of the mean. Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05.

Table (5): Effect of oral administration of colloids on total protein (TP) and total bilirubin (T.Bil.) of hypercholesterolemic rats

Colloids / Groups	TP(g/dl) Mean ±SD	T.Bil(mg/dl) Mean± SD
Control (-)	8.9±1.40 a	0.21±0.02 d
Contro (+)	5.8±0.60 d	0.66±0.06 a
Carob seeds	7.8±1.60 b	0.49±0.18 c
Sodium alginate	6.7±0.90 c	0.53±0.10 b
Propolis	7.9±1.10 b	0.25±0.04 d

Values denote arithmetic means ± Standard deviation of the mean. Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05.

Table (6): Effect of oral administrationof colloids on liver enzymes(AST-ALT-ALP)on hypercholesterolemic rats

Colloids / Groups	AST(U/L)Mean±SD	ALT(U/L)Mean±SD	ALP(U/L)Mean±SD
Control (-)	72.4±0.50b	22.6±2.50b	139±2.10 c
Contro (+)	150.9±2.90a	26.5±2.20a	212.5±0.70 a
Carob seeds	69.1±2.10 c	14.8±2.00c	145.6±3.30bc
Sodium alginate	60.3±2.20 d	11.7±1.50c	152.2±2.40 b
Propolis	70.2±2.10 b	20.1±1.50b	142.3±2.50bc

Values denote arithmetic means ± Standard deviation of the mean. Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05.

Table (7): Effect of oral administration of colloids, on kidney functions (creatinine, urea and uric acid) on hypercholesterolemic rats

Colloids / Groups	CREATININE (mg/dl)Mean ± SD	Urea(mg/dl) Mean ± SD	(mg/dl) Mean ± SD
Control (-)	0.32±0.01d	21.1±2.50c	1.36±0.94 b
Contro (+)	0.5±0.10a	36.5±3.70a	3.62.±1.09 a
Carob seeds	0.39±0.03c	20±2.00c	1.6±0.70 b
Sodium alginate	0.44±0.03b	28±2.00b	2±0.20 b
Propolis	0.37±0.08c	17±2.00d	1.5±0.60 b

Values denote arithmetic means ± Standard deviation of the mean. Means with different letters (a, b, c, d) in the same column differ significantly at p≤0.05 .

3. Histopathological results

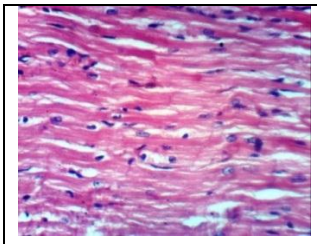
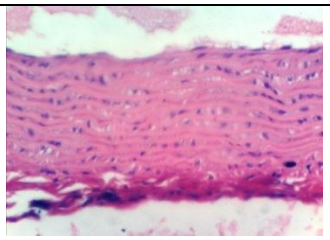
	

Photo (1): Heart of rat from control "-" rat's group 1 showing normal cardiac myocytes.	**Photo (2):** Aorta of rat from group (1cotrol"-"rats) showing no histopathological changes.)

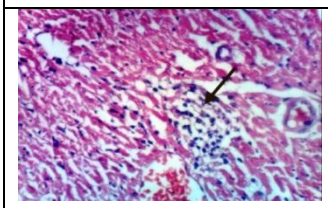
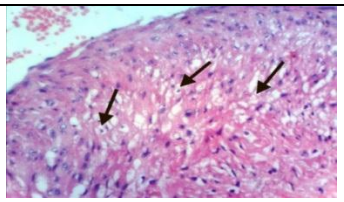

	

Photo (3): Heart of rat from hyercholesterolemic control"+" rats group 2 showing focal necrosis of cardiac myocytes associated with inflammatory cells infiltration.	**Photo (4):** Aorta of rat from hypercholesterolemic,(control"+" rats) group 2 showing marked vacuolations of tunica media.

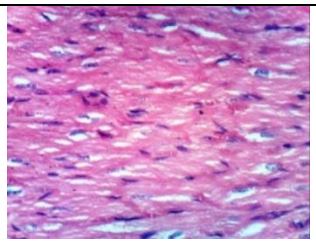
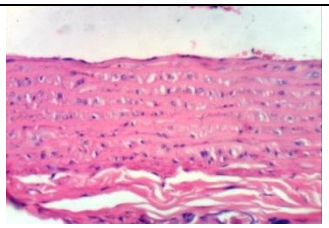
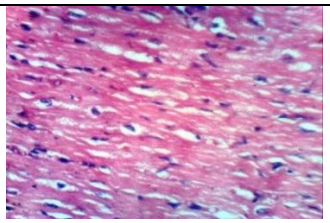
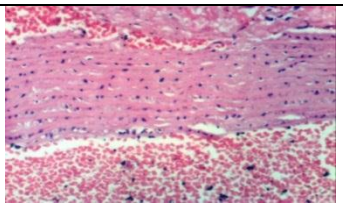

	

Photo (5): Heart of rat from hypercholesterolemic carob seeds powder group 3, showing no histopathological changes	**Photo (6):** Aorta of rat from hypercholesterolemic carob seeds powder group 3, showing no histopathological changes.

. 	
Photo (7): Heart of rat from hypercholesterolemic Na-alginate group 4, showing no histopathological changes.	**Photo (8):** Aorta of rat from hypercholesterolemic Na-alginate group 4, showing no histopathological changes.

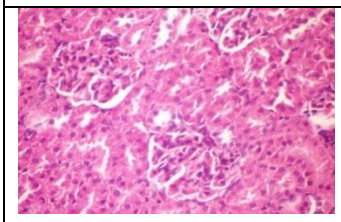
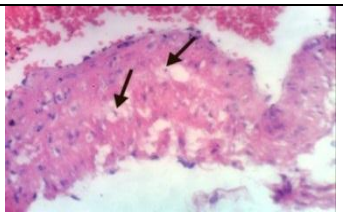

	

Photo (9): Kidney of rat from group 5, (propolis) showing no histopathological changes .	**Photo (10):** Aorta of rat from group 5, hypercholesterolemic propolis showing focal vacuolations of tunica media.

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تأثير الجينات الصوديوم وصمغ النحل ومسحوق بذور الخروب على الجرذان البيضاء المصابه بارتفاع الكوليسترول

منى ابراهيم محمد نجا

قسم الاقتصاد المنزلي (تغذية وعلوم الأطعمة) - كلية التربية النوعية
جامعة المنوفية

الملخص العربي

أجريت هذة الدراسة لمعرفة التأثير الوقائى للحد من إرتفاع الكوليسترول وتصلب الشرايين بإستخدام بعض الغرويات (بذور الخروب ,صمغ النحل , وألجينات الصوديوم) والتى إستخدمت بجرعة 500 ملجم /كجم من وزن الجسم لمدة 42يوم لتحسين مستويات الدهون (TC,TG,HDL-c,LDL-c,VLDL-c and AI) وبعض العوامل الأخرى مثل مستوى الجلوكوزفى الدم , بالإضافة إلى نشاط انزيمات الكبد ووظائف الكلى 0 تم استخدام 25فأر من ذكور الألبينو البيضاءالتى تتراوح أوزانهم بين 180-200جم عند بداية التجربة .تم تقسيمهم إلى خمس مجموعات تضم كل مجموعة 5 من الفئران استخدمت إحدى المجموعات كمجموعة ضابطة سالبة بينما المجموعات الأخرى تم تغذيتهم بإستخدام 1.5% كوليسترول +10% دهن حيوانى لمدة 15يوم وتم عزل مجموعة منهم كمجموعة ضابطة موجبة , وباقى المجموعات تم إعطائها عن طريق الفم أى من... جرعة من بذور الخروب , ألجينات الصوديوم وصمغ النحل كل على حدى بجرعات 500ملجم/كجم من وزن الجسم على التوالى لمدة 42 يوما . وقد أوضحت النتائج الاتى : أدى استخدام (الغرويات) المختلفة الى انخفاض ملحوظ فى مستوى الكوليسترول الكلى , الجليسريدات الثلاثية , الليبووبروتين منخفض الكثافة ومنخفض الكثافة جداً , ومعامل تصلب الشرايين , بينما إرتفع معدل الليبوبروتين عالى الكثافة (HDL-c) . وأدى أيضاً إستخدام الغرويات إلى إنخفاض مستويات الجلوكوز (سكر الدم) مع تحسين وظائف كلا من الكبد والكلى . كما أثبتت التشريحات الهيستوباثولوجية توافقاً مع النتائج البيوكيميائية , وعلاوة على ذلك حدث تحسن فى معدل كفاءة الطعام المتناول . وتوصى الدراسة بأن الغرويات يمكن إستخدامها فى خفض مستوى إرتفاع الكوليسترول فى الدم .