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Effect of Garlic and Mackerel Fish on Rats Suffering From Obesity

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Abstract

The present work was conducted to study the effect of two levels from mackerel fish, garlic and their combinations on loss of weight, serum glucose, leptin hormone, lipid fraction and kidney functions of obese rats. Forty-eight albino rats (Sprague Dawley Strain) were divided into two main groups. The first main group (6 rats) fed on basal diet was considered control negative group. The second main group (42 rats) fed on high fat diet (HFD) for 6 weeks to induce obesity. Obese rats were randomly assigned to seven equal subgroups: The first subgroup fed on HFD as positive control group, subgroups 2 and 3 fed on high fat containing 2.5% and 5% garlic powder, respectively. Subgroup 4 and 5 fed on high fat diet containing mackerel fish, which provided the diets with 50% and 100% protein, respectively. Subgroup 6 and 7fed on high fat diet containing 2.5% garlic powdered and half amount of protein from mackerel fish and 5% garlic powdered and all amount of protein from mackerel fish, respectively.Feeding rats on high fat diet led to significant increase in weights, body weight gain %, serum "glucose, leptin hormone, cholesterol, triglyceride, low density lipoprotein-cholesterol, very low density lipoprotein-cholesterol, uric acid, urea nitrogen and creatinine, while high density lipoprotein cholesterol decreased, as compared to healthy rats fed on basal diet. Treating obese rats with all tested diet showed significant decrease in weight and body weight gain%, in addition to improve all parameters. The best results recorded for the group which treated with HFD containing 5% garlic powdered and 100 % of protein from mackerel fish. Our results indicated1 that garlic and mackerel fish enhances the health status of obese rats and reduced the weight gain.

Introduction

Obesity occurs when the body’s energy intake exceeds the body’s energy consumption for a prolonged period. The degree of obesity is characterized by the volume and number of adipocytes, which is regulated in the so-called adipocyte life cycle ***(Rayalam et al., 2008).*** Obesity is associated with many metabolic diseases, including cardiovascular disease, diabetes mellitus, high blood pressure, atherosclerosis, various cancers, and hyperlipidemia ***(Achike et al., 2011).*** Thus, treatmentstargeting the regulation of adipocyte size and numbermay provide a therapeutic approach ***(Rosen et al., 2000).***

Allium sativum, or commonly known as garlic, is a vegetable species that can be classified as either a food or a medicinal herb. A widely used plant product is cultivated all over the world. Garlic falls into a family of Amaryllidaceaeor the genus Allium. Its closest relatives in the onion genus include the onion, shallot, leek, rakkyo and chive ***(Block, 2010).***

Garlic contains at least 33 sulfur compounds, several enzymes and the minerals germanium, calcium, copper, iron, potassium, magnesium, selenium and zinc; vitamins A, B1 and C, fiber and water. It also contains 17 amino acids to be found in garlic: lysine, histidine, arginine, aspartic acid threonine, swine, glutamine, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan and phenylalanine ***(Josling, 2005).***

Interestingly it has been observed that chronic administration of raw garlic RG significantly reduced body weight, however the mechanism as to how garlic contributes to a reduction in body weight is still unclear. A study by ***Elkayam et al., (2003)***has showed\\ that allicin administered for 2-3 weeks reduced weight gain in fructose fed rats. Together with reducing glucose levels allicin also has the added advantage of decreased weight gain.

Lau et al., (2006)found that aged garlic extract was effective in lowering serum cholesterol and triglycerides. Study by ***Mahmoodi et al., (2006*)**conducted on 30 volunteer individuals with blood cholesterol higher than 245 mg/dl. The subjects ingested 5g raw garlic twice a day for 42 days and then refrained from garlic for next 42 days. After 42 days of garlic consumption the mean of blood total cholesterol ($p<0.001$) triglycerides ($p<0.01$) and fasting blood sugar FBS ($p<0.01$) were reduced significantly, while HDL-c significantly increased ($p<0.001$). Following 42 days of no garlic consumption total cholesterol ($p<0.001$), triglycerides and FBS ($p<0.05$) were significantly increased and HDL-c ($p<0.01$) decreased. The authors of this study concluded that consumption alone can decrease serum lipids and may be effective in mild cases, but should probably not be relied on as the main therapeutic agent for hyperlipidemia.

Nestel, (1990) reported that, fish oil decreases the cholesterol absorption in humans, by reduced the synthesis of cholesterol in the liver and lowered cholesterol secretion within VLDL-c ***Agren et al., (1996)*** showed that both fasting and postprandial triglyceride concentrations can be decreased with moderate intakes of long-chain n-3 fatty acids either from a fish diet or fish oil and that also pure DHA has a hypotriglyceridemic effect.

The beneficial health effect of dietary fish intake has been known for decades. The lower incidence of cardiovascular disease among populations consuming fish-rich diets has been attributed to a greater proportion of ω-3 polyunsaturated fatty acids (PUFAs) in fish oil. The mechanisms for the cardioprotective effect of fish intake may include antiarrhythmic effects, antithrombotic effects, anti-inflammatory effects, hypotensive effects, improved endothelial function, reduced growth of atherosclerotic plaque, and a hypolipidemic effect ***(Geleijnse et al., 2002 andConnor, 2000).*** Although the triacylglycerol lowering effect of ω-3 PUFA is evident in normal and hypertriglyceridemichumans and animals ***(Harris 1996).***Therefore,thepresent studywas aimed to investigate the effects of supplemented high fat diet with garlic and mackerel fish on rats suffering from obesity.

Materials and Methods

Materials

- Casein, all vitamins, minerals, cellulose, L -Cystine and choline chloridewere purchased from El-Gomhoria Company, Cairo Egypt.
- Hydrogenated oils, soy oil, starch, sucrose, garlic powder and mackerel fish were purchased from local market, Cairo, Egypt.

- Normal male albino rats (48) of Sprague Dawley Strain obtained from the Laboratory Animal Colony. Ministry of Health and Population, Helwan, Cairo, Egypt.
- Kits: kits used to determine serum glucose, leptin, cholesterol, triglycerides, HDL-c, uric acid, urea nitrogen, creatinine; Aspartate Amino Transferase (AST), Alanine Amine Transferase (ALT) and Alkaline phosphate (ALP) were obtained from Gama tread Company, Cairo, Egypt.

Methods

Preparation of mackerel fish:

Raw mackerel fish was firstly eviscerated to separate the head, fins, tail, viscera and backbone, and then the body cavity of fish **was** washed with tap water to remove any traces of blood.

Cooking of mackerel fish:

Mackerel was roasted in electrical oven at 260°C for 20 – 30 minutes. Then, mackerel fish was minced by passing through a home meat chopper and mixed well, and then the mackerel fish was dried in oven at 50°C and grind.

The chemical analysis of mackerel fish and flaxseeds compositions:

Moisture, ash, total protein, total fat were determined according to ***A.O.A.C. (1990).***

Biological Investigation:

Male albino rats Sprague Dawley Strain (48 rats) weighing 150 ± 10 g were housed in well-aerated cages under hygienic condition and fed on basal diet for one week for adaptation according to ***Reeves et al.,***

(1993).After adaptation period, the rats were divided into two main groups as follows:

The first main group (6 rats) fed on basal diet containing (as a control negative group)***.The second main group (42 rat)*** was fed 6 week on high fat diet HFD containing hydrogenated oils 19%, soy oil 1%to provide essential fatty acids, sucrose 10%, casein 20%, cellulose 5%, vitamin mixture 1%, salt mixture 3.5%, choline chloride 0.25% and the remainder is corn starch to induce obesity in rats ***(Min et al., 2004).*** After these periods, the mean value of body weight gain % (BWG%) was estimated in the two main groups (control –ve group fed on basal diet and obese group fed on HFD), also blood samples were collected from all rats to estimate the levels of cholesterol and triglycerides (healthy rats was 65.00 ± 4.151 mg/dl cholesterol and 46.125 ± 3.270 mg/dl triglycerides), while the second main group recorded (140.236 ± 6.678 mg/dl cholesterol and 75.00 ± 5.800 mg/dl triglycerides), then the rats in the second main group were divided into seven subgroups (n = 6 each) according to the following scheme:

Subgroup 1: six rats fed on high fat diet, as a positive control.
Subgroups 2 and 3: fed on high fat diet containing 2.5% and 5% garlic powder, respectively.
Subgroups 4 and 5: fed on high fat diet containing half amount and all amount of protein from mackerel fish, respectively.
Subgroup 6 and 7: fed on high fat diet containing 2.5% garlic powdered and half amount of protein from mackerel fish and 5% garlic powdered and all amount of protein from mackerel fish, respectively.

During the experimental period (4 week), the diets consumed and body weights were recorded every week. At the end of the experiment, the rats were fasted overnight, then the rats were anaesthetized and sacrificed, and blood samples were collected from the aorta. The blood samples were centrifuged and serum was separated to estimate some biochemical parameters, i.e. serum total cholesterol according to ***Allain et al., (1974),***triglycerids ***Fossati et al., (1982),*** high density lipoprotein **Burstein (1970)**, low density lipoprotein and very low density lipoprotein ***Friedwald et al., (1972),*** glucose ***Trinder, (1959),*** uric acid ***Fossati et al., (1980),*** urea nitrogen ***Patton and Crouch, (1977),*** creatinine ***Bohmer, (1971)***and serum leptin hormone ***Guillaume et al., (1996).***

Liver and kidney were separated from each rat and weighted to calculate the liver and kidney to body weight %. Results of biological evaluation of each group were statistically analyzed (mean ± standard deviation and one way ANOVA test) using SAS package and compared with each other using the suitable test (least significant differences at $P< 0.05$ **(*Steel et al., 1980).***

Results and Discussion

Chemical Composition of Mackerel Fish (g/100g)

The percentage of protein was highly in roasted mackerel fish 20.95%, followed by total lipid 25.87, while the mackerel fish does not contain any carbohydrate, respectively. Roasted mackerel fish does not contain any fiber and contain 3.90% and 7.23 % ash and moisture, respectively. In this respect, ***Yu Wei Feng et al., (2012)*** reported that, crude protein, total lipids, moisture and total ash contents of mackerel fish ranged between 21.46%-22.75%, 2.24%-8.23%, 69.7%-74.9%, and 1.25%-1.63%, respectively.

Effect of Garlic and Mackerel Fish on feed intake as well as weights and body weight gain% of Rats ObesitySuffering.

The mean value of feed intake in the positive control group decreased than that of the negative control group. The two levels of garlic, mackerel fish and their combinations increased the mean value of feed intake, than that of the positive control group (Table 2). High fat diet increased the mean values of final weight and body weight gain % significantly (P≤0.05), as compared to the negative control group. All HFD treated groups showed significant decrease P≤0.05 in the mean value of final weight and body weight gain %, as compared to the positive control group. Treating obese groups with the low levels from garlic and mackerel fish (as a combination)and also the high levels2.5% garlic and 50% of protein from mackerel fish and 5% garlic and 100% of protein from mackerel fishrecorded the highest decrease in the mean value of body weight gain %, as compared to healthy rats, obese rats and other treated groups.

Obesity has become a serious worldwide healthcare problem, which is becoming increasingly prevalent among young adults and children ***(WHO, 1998 and BMA, 2005).*** It is therefore of great importance to help young overweight adults to lose weight. Inclusion of fish in a weight-loss-diet has been shown to have positive effects on several health-related variables ***(Mori et al., 1999),*** which could be due to omega3 fatty acids or other seafood constituents, such as fish proteins as reported in animal studies ***(Tremblay et al., 2007).***

Beneficial effects of fish consumption in relation to cardiovascular health have been thoroughly described, and mainly attributed to omega3 fatty acids ***(Dolocek et al ., 1991).*** Studies in rodents have demonstrated that marine omega3 fatty-acid-enriched diet decrease adipose growth and increase b-oxidation **(*Nakatani et al., 2003).*** Additionally, taurine, an amino acid abundant in fish protein, has been suggested to decrease body weight ***(Fujihira et al., 1970).***

Kim et al., (2011) suggest that garlic may have a potential benefit in preventing obesity. On the other hand,***Rosen et al., (2000)*** reported that, garlic supplement significantly decreased fat accumulating gen.***Yoonet al., (2005)*** reported that garlic, associated with significant reductions in body weight gain and fat mass in HFD-treated Sprague-Dawley (SD) rats.

Effect of Garlic and Mackerel Fish on Serum Glucose of Rats Obesity Suffering.

The effect of two levels of (garlic, mackerel fish and their combination) on serum glucose and leptin of obese rats presented in Table (3).The mean value of serum glucose was increased significantly P≤ 0.05 in positive group fed onHFD diet (obese rats), as compared to the negative control group (healthy rats).The mean value of serum glucose was decreased in all treated groups which were fed on high fat diet with garlic, mackerel fish and their combination, as compared to the positive control group.The highest decrease in serum glucosewas recorded for the HFD groups, treated with the diets containing low and high levels from the combination of garlic and mackerel fish2.5% garlic and 50% of protein from mackerel fish and 5% garlic and 100% of protein from mackerel fish.***Chiang et al., (1995) and Miura et al.,(1998)*** reported that, fish oil or dietary fish decreased glucose concentration and improved glucose tolerance by increasing insulin secretion capacity from pancreatic beta cells.

Most of the studies showed that garlic could reduce blood glucose level in diabetic mice and rabbits ***(Ohaeri, 2001).*** A study was conducted to evaluate oral administration of garlic extract for 14 days on the level of serum glucose. The result of that study showed significant decrease ($p<0.05$) in serum glucose, while increased serum insulin in diabetic mice, but not in normal mice. ***(Eidi et al. 2006).***

Effect of Garlic and Mackerel Fish on Serum Cholesterol and Triglyceride of Rats ObesitySuffering.

The mean value of serum leptin was increased by about 142.45% in obese rats (positive control group), than that of healthy rats (negative control group). All HFD treated groups decreased the mean value of serum leptin significantly $p\leq0.05$, as compared to the positive control group. On the other hand, serum leptin was decreased gradually with increasing the level of garlic, mackerel fish and their combination, than the positive group.The highest decrease in serum leptin was recorded for the groups, which were treated by the combination of garlic (5%) and mackerel fish which provided the diet with (100% protein), because this treatment decreased the mean value of serum leptin, as compared to other treated groups. This treatment decreased the mean value of serum leptin by about 39.18%, than that of the positive control group.

In this respect, leptin promotes weight loss by two different mechanisms. It reduces appetite, and thus food intake, and at the same time increases energy expenditure ***(Murakami et al., 2007 and Kuroda et al., 2010).***Higher leptin concentrations have been prospectively implicated as an independent risk factor for stroke, coronary artery disease, and myocardial infarction **(*Soderberg et al., 1999).*** Prospective studies have shown that a diet rich in fish or fish oil is related to a low incidence of cardiovascular disease ***(Daviglus et al., 1997).***The mechanisms of the protective effect of fish oil on cardiovascular risk have been attributed mainly to the high concentration of omega3 polyunsaturated fatty acids and their antithrombotic action and modification of immunological processes ***(Leaf, 1990).***

Yoonet al., (2005) reported that garlic, associated with significant reductions in body weight gain and fat mass in HFD-treated rats. Also =***Kim et al., (2013)*** suggested that *Allium sativum L*. (garlic) stem extract (ASSE) may ameliorate obesity, insulin resistance and oxidative damage in high-fat diet-induced obese mice.

The effect of two levels of garlic (2.5% and 5%), mackerel fish (fish provided the diets with 50% and 100% protein) and their combination 2.5% garlic and fish provided the diets with 50% protein and 5% garlic and fish provided the diets with 100% protein) on serum cholesterol, triglycerides, high density lipoprotein-cholesterol (HDL-c), low density lipoprotein-cholesterol (LDL-c) and very low density lipoprotein-cholesterol (VLDL-c)of obese rats presented in Table (4 and 5).

Effect of Garlic and Mackerel Fish on Serum Lipoproteins of Rats ObesitySuffering.

The mean value of total serum cholesterol and triglycerides was increased significantly P≤0.05 in the positive control group, as compared to the negative control group. All HFD treated groups showed significant decrease P≤0.05 in serum cholesterol, as compared to the positive control group. The highest decrease in serum cholesterol between all HFD tested groupswas recorded for the group, which treated with the combination of 5% garlic and mackerel fish, which provided the diet with 100% protein, this treatment decreased the mean value of serum cholesterol by about 35.22%, than that of the positive control group (Table 4).

All HFD treated groups with two levels of garlic, mackerel fish and their combination showed significant decrease P≤0.05 in serum triglyceride, except that group, which were treated with 2.5% garlic, and the group treated with mackerel fish, which provided the diet with 50% of protein. The highest levels of garlic and mackerel fish together (as a combination) recorded the best results in serum triglyceride.

The mean value of serum LDL-c and VLDL-c were decreased significantly P≤ 0.05, while HDL-c was increased in the positive control group (obese rats), as compared to the negative control group (healthy rats) (Table 5).All HFD treated groups with garlic; mackerel fish and their combination showed significant increase in serum HDL-c and decreased the mean values of serum LDL-c and VLDL-c, as compared to the positive control group.The best results in the mean value of serum lipoproteins recorded for the HFD group, which treated with high fat diet containing 5% garlic and mackerel fish which provided the diet with 100% protein, this treatment increased the mean value of serum HDL-c by about 43.75%, and decreased the mean values of serum LDL-c and VLDL-c by about 56.29% and 35.73% respectively, than that of the positive control group.

Dietary fat is considered one of the important environmental factors contributing to the obesity ***(Peters, 2003).*** Fat content is one of the main factors influencing the energy density of diets and an increase in energy density was shown to result in excess intake of calories; passive over consumption in humans in turn promotes the development of obesity ***(Westerterp-Plantenga, 2004).***

Zhang et al., (1993) demonstrated that, different fish proteins in the diet have different effects on cholesterol metabolism. On the other hand, ***Lowe et al., (1997)*** stated that, dietary fish oils, which are rich in omega-3 fatty acids, reduced plasma lipid levels in both normollipidemic and hyperlipidemic subjects. ***Schaefer et al.,(1996) and Shiau et al., (1999)*** reported that fish oil supplements and diets containingfish are enriched with eicosapentaenoic [20:5(omega3)] and docosahexaenoic [22:6(omega3)] acids and have been found to reduce plasma levelsof triglycerides, especially in the postprandial state. While ***Viejo et al., (1999)*** showed that, a 10-day application of a small supplementation of ω-3 fish oil changes the LDL-c composition, leading to less atherogenic index. ***Connor, (2000)*** reported that dietary omega3 fatty acids might ameliorate the atherosclerotic process itself, which is the cause of coronary artery disease. Populations that consume more omega3 fatty acids from fish have a lower incidence of coronary artery disease.

Garlic (*Allium sativum L.)* possesses many healthful properties that are related to its bioactive compounds ***(Leelarungrayub et al., 2006).*** Consumption of garlic is very helpful in regulating plasma lipid levels ***(Lau, 2006)***as well as plasma anticoagulant activity ***(Lawson et al., 1992)***and in prevention of the atherosclerosis process ***(Rahman et al., 2006).***

Health claims advertising garlic's universal ability to lower cholesterol level and decrease lipid peroxidation in order to inhibit plaque formation. *In vitro* studies clearly have shown that, it has an ability to suppress low density lipoprotein (LDL) and an increased resistance of LDL to oxidation ***(Lau, 2006).***

Jeyaraj et al. (2006) reported that after 60 days of supplementation by garlic fermented with the mold *Monascuspilosus,*low-density lipoprotein, serum triglyceride and very low density lipoprotein, were reduced by 21, 37, and 36.7%, respectively.

Effect of Garlic and Mackerel Fish on Kidney Function of Rats ObesitySuffering.

Results in Table (6) illustrate effect of high fat diet containing two levels of garlic, mackerel fish and their combination on serum uric acid, urea nitrogen and creatinine "mg/dl" of obese rats.

The mean values of serum uric acid urea nitrogen and creatinine were increased significantly P≤ 0.05 in rats suffering from obesity, than that of healthy rats.Serum uric acid, urea nitrogen and creatinine were decreased significantly P≤0.05 in obese groups, which were treated with the two levels of garlic, mackerel fish and their combinations.The highest decrease in serum uric acid, urea nitrogen and creatinine recorded for the HFDgroups which were treated with high fat diet containing 2.5% garlic and mackerel fish which provided the diet with 50% protein and 5% garlic and mackerel fish which provided the diet with 100% protein.

Fassett, et al., (2010) reported that, Omega-3 polyunsaturated fatty acids decrease blood pressure, a known accelerant of kidney disease progression. Well-designed, adequately powered, randomized, controlled clinical trials are required to further investigate the potential benefits of omega-3 polyunsaturated fatty acids on the progression of kidney disease and patient surviva ***Donadio, (1991)*** reported that, Omega-3 polyunsaturated fatty acids may limit the production or action of cytokines and eicosanoids evoked by the initial or by repeated immunologic renal injury.***Friedman et al., (1996)***reported that omega-3 fatty acids might have clinical benefits; formal recommendations encouraging omega-3 supplementation of dialysis patients are premature until long-term and adverse effects are better defined.

Maldonado et al., (2003) reported that, the protective effect of aged garlic extract (AGE) was associated with the decrease in the oxidative stress and the preservation of manganese superoxide dismutase, glutathione peroxidase, and glutathione reductase activities in renal cortex. These data suggest that AGE may be a useful agent for the prevention of gentamicin GM-nephrotoxicity.

Table (1): Chemical Composition of Mackerel Fish (g/100g)

Nutrient Proximate	Mackerel Fish(Roasted)
Water	7.23
Protein	20.95
Total lipid (fat)	25.87
Carbohydrate, by difference	---
Fiber, total dietary	---
Ash	3.90

Table (2): Effect of Garlic and Mackerel Fish on feed intake as well as weights and body weight gain% of Rats ObesitySuffering.

Groups		Feed intake (g/day/rat)	Initial weight (g)	Final weight (g)	BWG%
Control (-ve)		16.500	154.00 ^{b} ± 6.00	180.33 ^{f} ± 5.131	17.097 ^{d} ± 1.334
Control (+ve)		15.00	215.00 ^{a} ± 4.214	287.67 ^{a} ±11.239	33.800 ^{a} ± 0.989
Obese rats fed on HFD	containing 2.5% garlic	17.545	216.00 ^{a} ± 10.532	270.67 ^{b} ±11.846	25.310 ^{b} ± 2.607
	containing 5% garlic	18.00	215.00 ^{a} ± 11.490	260.33 ^{bcd} ± 5.686	21.08 ^{bc} ± 2.113
	containing 50% of protein from mackerel fish	16.00	221.00 ^{a} ± 4.00	265.67 ^{bc} ± 7.505	20.212 ^{c} ± 1.264
	containing 100% of protein from mackerel fish	17.234	217.33 ^{a} ± 6.507	254.33 ^{bcd} ± 10.066	17.202 ^{d} ± 1.676
	containing 2.5% garlic and 50% of protein from mackerelfish	16.232	220.00 ^{a} ± 6.358	246.67 ^{d} ± 7.637	12.122 ^{e} ± 1.084
	containing 5% garlic and 100% of protein from mackerel fish	16.500	217.00 ^{a} ± 7.557	226.00 ^{e} ± 7.637	4.147 ^{f} ± 0.213

- Values are expressed as mean ± SD.
- Significant at $p<0.05$ using one way ANOVA test.
- Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

Table (3): Effect of Garlic and Mackerel Fish on Serum Glucose of Rats Obesity Suffering.

Groups \ Parameter		Glucose mg/dl	Leptin mg/dl
Control (-) group		109.500 [d] ± 0.577	5.300 [g] ± 0.424
Obese rats fed on HFD	only (control +ve)	143.500 [a] ± 2.081	12.850 [a] ± 0.810
	containing 2.5% garlic	129.750 [b] ± 4.031	10.440 [b] ± 0.425
	containing 5% garlic	118.750 [c] ± 2.629	9.562 [c d] ± 0.426
	containing 50% of protein from mackerel fish	133.500 [b] ± 3.316	9.945 [b c] ± 0.461
	containing 100% of protein from mackerel fish	119.500 [c] ± 1.732	8.870 [e] ± 0.215
	containing 2.5% garlic and 50% of protein from mackerelfish	108.500 [d] ± 4.041	8.967 [d e] ±0.065
	containing 5% garlic and 100% of protein from mackerel fish	110.00 [d] ± 8.082	7.815 [f] ± 0.397

All results are expressed as mean ± SD

Values in each column, which have different litters, are significant different (P < 0.05).

Table (4): Effect of Garlic and Mackerel Fish on Serum Cholesterol and Triglyceride of Rats ObesitySuffering.

Groups \ Parameter		Cholesterol mg/dl	Triglyceride mg/dl
Control (-) group		69.00 ^{e} ± 8.082	58.250 ^{d} ± 7.320
Obese rats fed on HFD	only (control +ve)	150.500 ^{a} ± 5.196	89.00 ^{a} ± 5.830
	containing 2.5% garlic	124.00 ^{b} ± 2.828	80.750 $^{a\,b}$ ± 6.075
	containing 5% garlic	112.000 ^{c} ± 9.521	64.00 $^{c\,d}$ ± 4.242
	containing 50% of protein from mackerel fish	133.500 ^{b} ± 6.350	79.00 $^{a\,b}$ ± 8.082
	containing 100% of protein from mackerel fish	123.500 ^{b} ± 14.433	72.500 $^{b\,c}$ ± 8.660
	containing 2.5% garlic and 50% of protein from mackerelfish	102.500 ^{cd} ± 2.886	63.250 $^{c\,d}$ ± 4.500
	containing 5% garlic and 100% of protein from mackerel fish	97.500 ^{d} ± 6.454	58.00 ^{d} ± 7.527

All results are expressed as mean $\pm$ SD

Values in each column, which have different litters, are significant different (P < 0.05)

Table (5): Effect of Garlic and Mackerel Fish on Serum Lipoproteins of Rats ObesitySuffering.

Groups \ Parameter		HDL-c mg/dl	LDL-c mg/dl	VLDL-c mg/dl
Control (-) group		43.750 [a] ± 3.500	14.100 [f] ± 3.239	11.650 [d] ± 1.464
Obese rats fed on HFD	only (control +ve)	28.00 [e] ± 2.160	104.450 [a] ± 4.196	18.050 [a] ± 1.320
	containing 2.5% garlic	34.500 [d] ± 4.654	73.350 [b c] ± 3.742	16.150 [a b] ± 1.215
	containing 5% garlic	38.750 [b c] ± 0.957	60.450 [d] ± 7.925	12.800 [cd] ± 0.848
	containing 50% of protein from mackerel fish	35.750 [c d] ± 2.986	81.950 [b] ± 4.202	15.800 [a b] ± 0.848
	containing 100% of protein from mackerel fish	37.500 [b c d] ± 0.577	71.500 [c] ± 12.124	14.500 [b c] ± 1.732
	containing 2.5% garlic and 50% of protein from mackerelfish	35.500 [c d] ± 1.732	51.600 [d e] ± 4.819	12.650 [cd] ± 0.900
	containing 5% garlic and 100% of protein from mackerel fish	40.250 [a b] ± 1.258	45.650 [e] ± 6.682	11.600 [d] ± 1.505

All results are expressed as mean ± SD

Values in each column, which have different litters, are significant different ($P < 0.05$)

Table (6): Effect of Garlic and Mackerel Fish on Kidney Function of Rats ObesitySuffering.

Groups	Parameter	Uric acid mg/dl	Urea nitrogen mg/dl	Creatinine mg/dl
Control (-) group		1.260^{c} ± 0.048	16.900^{e} ± 0.115	0.552^{d} ± 0.035
Obese rats fed on HFD	only (control +ve)	2.350^{a} ± 0.173	39.025^{a} ± 0.543	1.587^{a} ± 0.085
	containing 2.5% garlic	1.972^{b} ± 0.174	28.075^{b} ± 1.658	0.757^{c} ± 0.046
	containing 5% garlic	2.025^{b} ± 0.086	17.00^{e} ± 0.905	0.760^{c} ± 0.033
	containing 50% of protein from mackerel fish	1.875^{b} ± 0.095	23.250^{c} ± 0.960	0.840^{b} ± 0.049
	containing 100% of protein from mackerel fish	1.860^{b} ± 0.110	22.800^{c} ± 0.594	0.780$^{b\,c}$ ± 0.046
	containing 2.5% garlic and 50% of protein from mackerelfish	1.440^{c} ± 0.127	19.325^{d} ± 0.713	0.757^{c} ± 0.033
	containing 5% garlic and 100% of protein from mackerel fish	1.297^{c} ± 0.185	19.400^{d} ± 0.616	0.752^{c} ± 0.030

All results are expressed as mean ± SD

Values in each column, which have different litters, are significant different ($P < 0.05$)

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تأثير الثوم و سمك الماكريل علي الفئران المصابة بالسمنة

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الملخص العربي

اجريت هذه الدراسه لمعرفه تأثير مستويين من سمك الماكريل و خليطهما على خفض الوزن , و مستويات الجلوكوز, و هرمون الليبتين, و جزيئات الدهون, و وظائف الكلى للجرذان البدينه. تم تقسيم ٤٨ جرذ من نوع الألبينو سلاله (Sprague dewily) الي مجموعتين رئيسيتين. المجموعة الرئيسية الأولي (٦ جرذان) تم تغذيتها علي غذاء اساسي و استخدم كمجموعة ضابطة سلبية. المجموعة الثانية الرئيسية الثانية (٤٢ من الجرذان) تم تغذيتها علي غذاء مرتفع الدهون الدهون لمدة ٦ أسابيع لاحداث السمنة " البدانة " تم تقسيم الجرذان البدينة عشوائيا الي سبع مجموعات فرعية متساوية : المجموعة الفرعية الاولي تم تغذيتها علي غذاء مرتفع الدهن و استخدمت كمجموعة ضابطة ايجابية, و المجموعات الفرعية ٢,٣ تم تغذيتها علي غذاء مرتفع الدهن يحتوي علي ٢,٥ % و ٥% من ثوم مطحون, علي التوالي. المجموعة الفرعية ٤ , ٥ تم تغذيتها علي غذاء مرتفع الدهن يحتوي علي سمك الماكريل الذي يمد الوجبات بنسبة ٥٠ % و ١٠٠ % بروتين, علي التوالي. المجموعة الفرعية ٦, ٧ تم تغذيتها علي غذاء مرتفع الدهن يحتوي علي ٢,٥ % من مسحوف الثوم و ٥٠% من كمية البروتين من اسماك الماكريل و ٥% من مسحوق الثوم و ١٠٠% من كمية البوتين من اسماك الماكريل, علي التوالي. أدت تغذية الجرذان علي غذاء مرتفع من الدهن الي حدوث زيادة معنوية في الاوزان, جلوكوز الدم, هرمون الليبتين, الكوليسترول, الجليسريدات الثلاثية, كوليسترول الليبوبروتينات منخفض الكثافة, كوليسترول الليبوبروتينات متخفض الكثافة جدا, حمض اليوريك, نيتروجين اليوريا, و الكرياتينين, في حين انخفضت نسبة كوليسترول الليبوبروتينات عالي الكثافة مقارنة بالجرذان الغير مصابة بالسمنة و التي تم تغذيتها علي غذاء اساسي, معاملة الجرذان البدينة بكل الوجبات المختبرة اظهر انخفاضا ملحوظا في الوزن و النسبة المئوية للزيلدة في الوزن, بالاضافة الي حدوث تحسن في جميع التقديرات, سجلت أفضل النتائج للمجموعة العاملة بغذاء مرتفع الدهن و المحتوية علي ٥% من مسحوق الثوم و ١٠٠% من كمية البروتين من سمك الماكريل, و تشير النتائج المتحصل عليها الي الثوم و سمك الماكريل تحسن الحالة الصحية للجرذان البدينة و تقلل من زيادة الوزن.