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Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flaxseeds on Weight Loss of Obese Rats

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Abstract:

The present work was conducted to study the effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flax seeds on the nutritional values, weights, percent of liver & kidney weights / body weights%, serum glucose, leptin hormone, lipid fraction, liver functions and kidney functions, of obese rats. Sixty male albino rats (Sprague Dawley Strain) were divided into two main groups. The first main group (6 rats) fed on basal diet containing 14% protein was considered negative control group. The second main group (54 rats) fed on high fat diet (HFD) for 6 weeks to induce obesity. Obese rats were randomly assigned to nine equal groups: The first group fed on HFD as positive control group, groups (2 and 3) fed on high fat low sodium diet containing mackerel fish which provided the diets with 14% and 22% protein, respectively. groups (4 and 5) fed on high fat low sodium diet containing 5% and 10% arabic gum, respectively. groups (6 and 7) six rats fed on high fat low sodium diet containing 5% and 10% flaxseeds. groups (8 and 9) fed on high fat low sodium diet containing [(mackerel fish which will be provided the diet with 14% protein + 5% Arabic gum + 5% flaxseeds) and (mackerel fish which provid the diet with 22% protein + 10% Arabic gum + 10% flaxseeds)], respectively. Treating obese rats with high protein diet from mackerel fish, Arabic gum, flaxseeds and their combination improved the mean value of feed intake and "decrease body weight gain % and the percent of liver and kidney weights / body weights%", as compared to the obese group (control positive group). All lipid fractions (cholesterol, triglycerides, LDL-c and VLDL-c), kidney functions (uric acid, urea nitrogen and creatinine) and liver enzymes (aspartate amino transferase AST, alanine amino transferase ALT and alkaline phosphatase ALP), glucose and leptin hormone decreased significantly $p<0.05$ in all tested groups, while HDL-c increased, as compared to the positive control group. High levels and low levels from themixture of tested materials recorded the best effects on serum parameters, comparing with other treated groups.

Key words:mackerel fish, flaxseeds, gum Arabic, high fat diet, rats, lipid profile, kidney functions, liver enzymes, glucose, leptin hormone and weight loss.

Introduction:

In recent decades, obesity has become a prominent health problem in many countries **(Cali and Caprio, 2008)**, because it is considered to be a risk factor associated with the genesis or development of various diseases, including cardiovascular disease, type 2 diabetes mellitus and metabolic syndrome, which resulting in an increasing morbidity and mortality **(Brown et al., 2009)**. Recent reports have proposed mechanisms to reduce obesity, including decreased energy/food intake and increased energy expenditure, decreased lipogenesis, and increased lipolysis and fat oxidation **(Wang and Jones, 2004*)***. Obesity is characterized by the accumulation of adipose tissue, which expands due to an increase in adipocyte size and number (**Furuyashiki et al., 2004)**.

Skov et al., (1999) found that obese subjects randomized to a high-protein intake (25% of energy) lost significantly more weight (8.8 vs 5.1 kg) after 6 mo compared with those on a low protein diet (12% of energy). On the other hand, **(Wolfe and Piche 1999)** reported that,one weight-loss and weight maintenance studies also showed that replacing some carbohydrate with protein improves the fasting lipid profile.

In young, overweight men, the inclusion of either lean or fatty fish, or fish oil as part of an energy-restricted diet resulted in ~1 kg more weight loss after 4 weeks, than did a similar diet without seafood. The addition of seafood to a nutritionally balanced energy-restricted diet may boost weight loss **(Thorsdottir et al., 2007)**. A daily fish meal into a weight-loss regimen was more effective than either measure alone at improving glucose-insulin metabolism and dyslipidemia. Cardiovascular risk is likely to be substantially reduced in over weight hypertensive patients with a weight-loss program incorporating fish meals rich in n-3 fatty acids (**Trevor et al., 1999)**.

Several epidemiological studies suggest that a high intake of dietary fiber, including gum arabic "GA", is associated with beneficial effects on fat metabolism **(Ali et al., 2009)**. Dietary fiber promotes satiation and satiety, alter glycaemic index, affects gastric emptying, gut hormone secretion and thus helps to manage weight **(Chandalia et al., 2000)**.

Recently, extracted flaxseed fiber added to bread was found to lower cholesterol in diabetics (**Thakur et al., 2009).** Flaxseeds contain ~30% dietary fibers of which one third are water-soluble (**Naran et al., 2008)**. Water extractable neutral monosaccharides from flaxseed were a mixture of polymers: arabinoxylans and various amount of galactose. Also, flaxseeds contain some pectins. Flaxseed fibers form highly viscous solutions upon hydration, which is similar to those observed for other gums**Warrand et al., (2005)[a]**.

Therefore, the present work was conducted to study the effect of low caloric and sodium diets in the presence of mackerel fish, Arabic gum and flaxseeds on weight loss of obese rats.

Materials And Methods:

Materials:

- Casein, all vitamins, minerals, cellulose, L -cystine and choline chloride were obtained from El–Gomhoriya Company, Cairo, Egypt.
- Hydrogenated oils, corn oil, starch, sucrose, mackerel fish, Arabic gum and flaxseeds were obtained from local market, Cairo, Egypt.
- Normal male albino rats (60) of spragueDawley Strain obtained from the Laboratory Animal Colony, Ministry of Health and Population, Helwan, Cairo, Egypt.
- Kits: kits used to determine serum cholesterol, triglycerides, HDL-c, glucose, AST, ALT, ALP, uric acid, urea nitrogen, creatinine and leptin were obtained from Gama trade 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 waswashed 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 minced by passing through a home meat chopper , mixed well, and then the mackerel fish was dried in oven at 50°C and ground.

Moisture, ash, total protein, crude fat were determined in flaxseeds and mackerel fish according to ***A.O.A.C.(1990)***, while carbohydrates were calculated by difference.

Biological Investigation:

Male albino rats Sprague Dawley strain (60 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 14% protein (as a control negative group). ***The second main group (54 rat)*** was fed 6 week on high fat diet HFD containing (hydrogenated oils 19%, corn 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 % was estimated in the two main groups (control –ve group fed on basal diet containing 14% protein and obese main group), also blood samples were collected from all rats to estimate the levels of cholesterol and triglycerides (healthy rats had 75.00 ± 5.051 mg/dl cholesterol and 38.125 ± 4.870 mg/dl triglycerides), while the second main group recorded (160.566 ± 6.678 mg/dl cholesterol and 75.00 ± 5.800 mg/dl triglycerides), then the rats in the second main group were divided into nine groups (n = 6 each) according to the following scheme:

Group 1: six rats fed on high fat and normal protein diet (20% fat and 14% protein) as a positive control. ***Groups 2 and 3:*** Fed on high fat low sodium diet* containing mackerel fish which provided the diet with 14% and 22% protein, respectively. ***groups 4 and 5:*** fed on high fat low sodium diet* containing 5% and 10% Arabic gum, respectively. ***groups 6 and 7:*** Fed on high fat low sodium diet* containing 5% and 10% flaxseeds, respectively. ***groups 8 and 9:*** Fed on high fat low sodium diet* containing (mackerel fish which provided the diet with 14% protein + 5% Arabic gum + 5% flaxseeds) and (mackerel fish which provided the diet with 22% protein + 10% Arabic gum + 10% flaxseeds), respectively.

During the experimental period (4 weeks), the diets consumed and body weights were recorded twice weekly. At the end of the experiment, the animals were fasted overnight, then the rats were anaesthetized and sacrificed, and blood samples were collected from the aorta. The blood samples were centrifuged and the serum was separated to estimate some biochemical parameters, i.e. serum cholesterol according to **(Allain et al., 1974)**, triglycerides **(Fossati and Principe (1982)**, high density lipoprotein HDL-c **(Burstein, 1970)**, low density lipoprotein LDL-c and VLDL-c calculated according to **(Friedwald et al., 1972)**, glucose **(Trinder 1959)**, uric acid **(Fossati et al., 1980)**, urea nitrogen **(Patton & Crouch, 1977)** and creatinine **(Bohmer, 1971)**, aspartate amine transaminase (AST) and alanine amine transaminase (ALT) **(Henry, 1974)**, ALP **(Belfield and Goldberg (1971) and** leptin hormoneaccording to**Guillaume and Bjorntorp (1996).**Liver and kidney of all groups was separated from each rat and weighted to calculate organs 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 and Torri, 1980)**.

Results And Discussion:

Chemical Composition of Flaxseeds and Mackerel Fish (g/100g)

Results of major chemical composition of flaxseeds and roasted mackerel fish presented in table (1).

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

Nutrient Proximate	Flaxseeds	Mackerel Fish (Roasted)
Water	7.17	7.00
Protein	19.29	63.23
Total lipid (fat)	42.16	25.80
Carbohydrate, by difference	28.88	---
Fiber, total dietary	26.3	---
Ash	2.500	3.97

The tabulated results represent the chemical composition of flaxseeds and roasted mackerel fish,including water, total carbohydrate, protein, fat, ash and crude fiber (on dry weight basis).Flaxseeds characterized with high amounts of total lipid, total carbohydrate including fiber. Meanwhile roasted mackerel fish characterized with high amounts of protein and total fat.The lowest amounts of nutrients in flaxseeds and roasted mackerel fish recorded for the water and ash.

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flaxseeds on Feed Intake and Body Weight Gain% of Obese Rats.

The effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flax seeds on feed intake and body weight gain% of obese rats presented in Table (2). The mean value of feed intake (g/day/rat) in the positive control group (obese group) fed on high fat diet decreased than that of the healthy rats fed on basal diet (control –ve group) (16.00g vs. 17.500g), respectively. Feeding obese group on high fat low sodium diet containing 14% and 22% protein from mackerel fish increased the mean value of feed intake, than that of the positive control group. On the other hand the mean value of feed intake increased in obese group treated with 22% protein from mackerel fish, than that of the group which treated with 14% from the same type of fish.

Treating obese groups with the two levels of Arabic gum (5% and 10%) decreased the mean value of feed intake(FI), than that of the positive control group, on the other hand the mean value of feed intake decreased gradually with increasing the level of Arabic gum. Feeding obese rats on high fat, low sodium diet containing 5% and 10 flaxseeds increased the mean value of feed intake than that of the positive control group. The mean value of feed intake of the group which fed on high fat, low sodium diet containing 10% flaxseed showed increased level, than that of the group fed on the same diet containing 5% flaxseed. The mean value of feed intake of the obese groups which treated with high fat, low sodium diet containing the mixture of (14% protein from fish, 5% Arabic gum and 5% flaxseed) and (22% protein from fish, 10% Arabic gum and 10% flaxseed) increased, than that of the positive control group.

The mean value of BWG% increased significantly $p<0.05$, in the obese group (control +ve), as compared to healthy group (control –ve). All treated groups showed significant decrease in BWG% $p\leq0.05$, as compared to the positive control group. The highest decrease in BWG% recorded for the group which treated with the high levels of all tested materials, followed by the low levels and the group which treated with 10% Arabic gum. The data presented in the same table revealed that, body weight gain % of the groups which treated with the (high and low levels) of all tested materials and the group treated with 10% Arabic gum decreased significantly $p\leq0.05$, as compared to the negative control group.

In this respect, **Wickelgren (1998**) defined the obesity, as an increase in mass of adipose tissue, confers a higher risk for metabolic diseases such as non-insulin-dependent diabetes, cardiovascular disease, and stroke and an increased incidence of morbidity. On the other hand, dietary fibers may also play a role in body weight regulation, through both hunger suppression and diminished nutrient absorption **(Henness and Perry, 2006)**. Flaxseeds contain ~30% dietary fibers of which one third are water-soluble and belonging to a group of heterogeneoues polysaccharides **(Naran et al., 2008).** They can affect multiple aspects of the gastrointestinal function such as gastric emptying rate and nutrient absorption rate in the small intestine **(Lairon et al., 2007)**.

Babiker et al., (2012)(GA) ingestion causes significant reduction in BMI and body fat percentage among healthy adult females. This effect could be exploited in the treatment of obesity.Several epidemiological studies suggest that a high intake of dietary fiber, including GA, is associated with beneficial effects on fat metabolism **(Slavin, 2003 and Ali et al., 2009)**. Dietary fiber promotes satiation and satiety, alter glycaemic index, affects gastric emptying, gut hormone secretion and thus helps to manage weight **(Chandalia et al., 2000)**.

Mori et al., (1999) reported that, incorporating a daily fish meal into a weight-loss regimen was more effective than either measure alone at improving glucose-insulin metabolism and dyslipidemia. Cardiovascular risk is likely to be substantially reduced in overweight hypertensive patients with a weight-loss program incorporating fish meals rich in n-3 fatty acids.**Thorsdottir et al., (2007)** reported that, in young, overweight men, the inclusion of either lean or fatty fish, or fish oil as part of an energy-restricted diet resulted in ~1 kg more weight loss after 4 weeks, than did a similar diet without seafood or supplement of marine origin. The addition of seafood to a nutritionally balanced energy-restricted diet may boost weight loss.

Table (2): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flaxseeds on Feed Intake and Body Weight Gain% of Obese Rats

Groups	**Parameters**	**Feed intake (g/day/rat)**	**Initial weight (g)**	**Final weight (g)**	**BWG%**
Control (-ve)		17.500	159.00 ^{b} ± 6.00	184.33 ^{e} ± 5.131	15.930 ^{d} ± 1.334
Control (+ve)		16.00	220.00 ^{b} ± 4.214	292.67 ^{a} ± 11.239	33.031 ^{a} ± 0.989
High fat diet containing	Mackerel fish PW with 14% protein.	18.545	221.00 ^{a} ± 10.532	273.67 ^{b} ± 11.846	23.832 ^{b} ± 2.607
	Mackerel fish PW with 22% protein.	19.00	220.00 ^{a} ± 11.490	265.33 ^{bcd} ± 5.686	20.604 ^{bc} ± 2.113
	5% Arabic gum	15.343	225.67 ^{a} ± 7.506	270.67 ^{bc} ± 5.859	19.940 ^{c} ± 1.069
	10% Arabic gum	14.00	224.67 ^{a} ± 4.511	255.33 ^{cd} ± 6.110	13.646 ^{e} ± 1.128
	5% flaxseeds	17.00	226.00 ^{a} ± 4.00	270.67 ^{bc} ± 7.505	19.765 ^{c} ± 1.264
	10% flaxseeds	18.234	222.33 ^{a} ± 6.507	259.33 ^{bcd} ± 10.066	16.641 ^{d} ± 1.676
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	17.232	224.00 ^{a} ± 6.358	251.67 ^{d} ± 7.637	12.352 ^{e} ± 1.084
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	17.500	221.00 ^{a} ± 7.557	230.00 ^{e} ± 7.637	4.072 ^{f} ± 0.213

- Values are expressed as mean ± SD. - Significant at $p \leq 0.05$ 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. - PW: Provided with.

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Organs Weight/Body Weight% of Obese Rats.

Liver and kidney weights / body weights % of obese rats increased significantly p<0.05, as compared to the negative control groups. Liver and kidney weights / body weights % of all treated groups decreased significantly, except group of rats which treated with mackerel fish which provided the diet with 14% protein, as compared to the positive control group.

The high levels of mackerel fish, Arabic gum and flaxseeds are more effect in reducing (liver and kidney weights / body weight %), as compared to the low levels from these materials.Treating obese rats with the high levels from the mixture of (mackerel fish, Arabic gum and flaxseeds) recorded the best results in decreasing liver and kidney weights/body weight %.

In this respect, **Schumann et al., (2003)** showed that the long-term use of 100/kg dietary ground flaxseed in laying hen diets reduced liver fat content and liver weight. The addition of the fatty liver supplement in the flaxseed diets also lowered liver malondialdhyde (MDA) content in hens.

Table (3): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Organs Weight/Body Weight% of Obese Rats

Groups \ Parameters		Organs Weight/Body Weight%	
		Liver	Kidney
Control (-ve)		2.52 ^{e}± 0.116	0.59 ^{f}± 0.039
Control (+ve)		3.52 ^{a}± 0.090	0.84 ^{a}± 0.044
High fat diet containing	Mackerel fish PW with 14% protein.	3.40 ^{a}± 0.100	0.80 $^{a\ b}$± 0.021
	Mackerel fish PW with 22% protein.	3.09 $^{b\ c}$± 0.095	0.69 $^{d\ e}$± 0.020
	5% Arabic gum	3.23 ^{b}± 0.015	0.74 $^{c\ d}$± 0.048
	10% Arabic gum	2.83 ^{d}± 0.110	0.70 $^{c\ d\ e}$± 0.010
	5% flaxseeds	3.16 $^{b\ c}$± 0.081	0.76^{bc}± 0.047
	10% flaxseeds	3.00 ^{c}± 0.103	0.68 $^{d\ e}$± 0.030
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	3.14^{bc}± 0.039	0.68 $^{d\ e}$± 0.030
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	2.64 ^{e}± 0.097	0.65 $^{e\ f}$± 0.026

- 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 letters similar or partially are not significant. - PW: Provided with.

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Lipid Profile of Obese Rats:

The effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flax seeds on serum cholesterol, triglycerides (Tg), 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). Feeding rats on high fat diet increased the mean value of serum (cholesterol, triglycerides, LDL-c and VLDL-c) while HDL-c decreased, as compared to normal rats fed on basal diet (control negative group).

Feeding rats on high fat, low sodium diets containing two levels of (mackerel fish, Arabic gum and flaxseeds) decreased the mean value of lipid profile, except HDL-c recorded significant increase, as compared to the positive control group. The high levels of mackerel fish, Arabic gum and flaxseeds are more effective in decreasing the mean values of serum (cholesterol, triglycerides, LDL-c and VLDL-c) and increasing the mean values of HDL-c, as compared to the low levels from these materials. Treating obese rats with the high levels from the mixture of (mackerel fish, Arabic gum and flaxseeds) improved lipid profile, than that of the other treated groups.

Dietary fat is considered to be 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).** Flaxseed or linseed **(Linumusitatissimum L.)** classified as a functional food, since it is a leading source of the dietary fiber and phytochemical including, flavonoids, lignans, phenolic acids, phytic acid, and tocopherols, and it is an abundant source of alpha-linolenic acid **(Oomah and Mazza, 1998 and Oomah 2001)**. Flaxseed is also a rich source of lignans, which have antioxidant activity **(Xue et al, 1992)** and therefore may also be of benefit in the prevention of cardiovascular disease **(Hertog et al., 1993)**.

Table (4): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Lipid Profile of Obese Rats.

Groups \ Parameters		Cholesterol	Tg	HDL-c	LDL-c	VLDL-c
		mg/dl				
Control (-ve)		78.218 ^{h} ± 3.100	38.107 ^{f} ± 2.074	48.218 ^{a} ± 2.010	22.378 ^{h} ± 2.717	7.621 ^{f} ± 0.415
Control (+ve)		187.247 ^{a} ± 7.060	93.368 ^{a} ± 2.839	18.572 ^{g} ± 0.658	146.001 ^{a} ± 11.410	18.673 ^{a} ± 0.567
High fat diet containing	Mackerel fish PW with 14% protein.	161.620 $^{c\ d}$ ± 7.440	76.489 ^{c} ± 3.529	26.636 ^{e} ± 2.228	119.614 $^{c\ d}$ ± 6.574	15.369 ^{c} ± 0.705
	Mackerel fish PW with 22% protein.	146.010 ^{f} ± 6.683	66.672 ^{d} ± 4.422	30.218 ^{d} ± 2.032	107.938 $^{e\ f}$ ± 4.771	13.333 ^{d} ± 0.884
	5% Arabic gum	170.832 ^{b} ± 7.376	79.599 $^{b\ c}$ ± 3.119	24.123 ^{f} ± 1.334	130.789 ^{b} ± 6.229	15.919 $^{b\ c}$ ± 0.623
	10% Arabic gum	156.465 $^{d\ e}$ ± 6.360	78.036 $^{b\ c}$ ± 3.294	29.202 ^{d} ± 2.124	111.655 $^{d\ e}$ ± 5.243	15.607 $^{b\ c}$ ± 0.658
	5% flaxseeds	168.090 $^{b\ c}$ ± 7.550	81.828 ^{b} ± 2.936	24.552 $^{e\ f}$ ± 1.605	127.172 $^{b\ c}$ ± 7.088	16.365 ^{b} ± 0.587
	10% flaxseeds	152.393 $^{e\ f}$ ± 6.506	71.182 ^{d} ± 3.978	30.218 ^{d} ± 2.032	107.938 $^{e\ f}$ ± 4.771	14.236 ^{d} ± 0.795
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	150.611 $^{e\ f}$ ± 7.682	67.836 ^{d} ± 4.169	34.547 ^{c} ± 2.053	102.497 ^{f} ± 5.404	13.566 ^{d} ± 0.833
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	127.056 ^{g} ± 5.000	56.327 ^{e} ± 3.751	39.477 ^{b} ± 1.412	76.313 ^{g} ± 5.585	11.265 ^{e} ± 0.750

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

Prasad et al., (1998) concluded that the reduction in hypercholesterolemic atherosclerosis by flaxseed is due to a decrease in serum total cholesterol and LDL cholesterol and that the anti-atherogenic activity of flaxseed is independent of its α-linolenic acid content.**Thakur et al., (2009)** reported that, extracted flaxseed fiber added to bread was found to lower cholesterol in diabetics**.** Also, **Pan et al., (2009)** reported that, flaxseed consumption lower both total and LDL-cholesterol, whereas flaxseed oil does not, and the role of lignans is still controversial.Thus, the responsible component for the assumed cardioprotective effect of flaxseeds may well be the fiber component.

Dietary fibers including GA bind bile acids and diminish their absorption in the terminal ileum. Then in the large intestine, degradation of GA releases the sequestered bile acids and the acidic pH generated during the fermentation process renders them insoluble and promotes their excretion in stool. This reduces their pool in the body and causes decreased fat digestion and absorption. Similarly, the hepatic formation of new bile acids requires cholesterol. Thus, prolonged ingestion of Gum Arabic may cause weight loss and reduction in cholesterol level in plasma **(Moundras et al., 1994).**

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 normolipidemic and hyperlipidemic subjects. ***Connor, (2000)*** reported that dietary n_3 fatty acids might ameliorate the atherosclerotic process itself, which is the cause of coronary artery disease. Populations that consume more n_3 fatty acids from fish have a lower incidence of coronary artery disease

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on serum glucose of Obese Rats.

The effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flax seeds on serum glucose (mg/dl) of obese rats presented in table (5). Feeding rats on high fat diet in the positive control group led significant increase $p \leq 0.05$ in serum glucose, as compared to healthy rats fed on basal diet (160.122 ± 6.094 mg/dl vs. 86.479 ± 4.834 mg/dl, respectively). The mean value of serum glucose increased by about 85.157% in the positive control group, than that of the negative control group.

All treated groups recorded significant decrease in serum glucose, as compared to the positive control group. Non-significant change observed in the mean value of serum glucose between the groups which treated with low levels from tested materials (mackerel fish, Arabic gum and flaxseed), the same trend was observed between the groups which treated with the high levels from these materials.

Results in this table revealed that, feeding obese rats on high fat, low sodium diet containing (mackerel fish provided with 22% protein, 10% Arabic gum and 10% flaxseed) led to significant decrease $p \leq 0.05$ in serum glucose, as compared to other treated groups. This treatment decreased the mean value of serum glucose by about 30.198%, than that of the positive control group. This treatment recorded the best results in serum glucose, followed by the obese group treated with 10% Arabic gum.

Table (5): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on serum glucose of Obese Rats.

Groups \ Parameter		Serum glucose mg/dl
Control (-ve)		86.479 [f] ± 4.834
Control (+ve)		160.122 [a] ± 6.094
High fat diet containing	Mackerel fish PW with 14% protein.	146.574 [b] ± 4.696
	Mackerel fish PW with 22% protein.	127.974 [c d] ± 4.275
	5% Arabic gum	142.574 [b] ± 4.197
	10% Arabic gum	123.931 [d] ± 3.761
	5% flaxseeds	144.748 [b] ± 3.895
	10% flaxseeds	129.681 [c d] ± 3.177
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	130.147 [c] ± 4.297
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	111.767 [e] ± 4.438

- 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 letters similar or partially are not significant. - PW: Provided with.

In this respect**, Bjorntorp, (1991**) reported that, the influence of obesity on type 2 diabetes risk is determined not only by the degree of obesity but also by where fat accumulates. Increased upper body fat including visceral adiposity, as reflected in increased abdominal girth or waist-to-hip ratio, is associated with the metabolic syndrome, type 2 diabetes, and cardiovascular disease.

Hu et al., (2007) cleared that(SDG) is presumed to act as precursor to in vivo antioxidant lignans and may contribute to the prevention and delayed progression of diabetes given that oxidative stress is secondary to hyperglycemia and hyperinsulinemia and that depletion of antioxidants is implicated in diabetes. **Abuelgassim (2010)** found that serum glucose concentration of diabetic rats treated with flaxseed extract for 2, 3 and 4 weeks was significantly decreased. Study showed that(FS)extract has a hypoglycaemic effect against alloxan diabetic rats. **Hano et al., (2013)** proposed that the first evidences for a mechanism of action involving the inhibition of the pancreatic α-amylase (EC 3.2.1.1) by flaxseed – derived lignans.

Nasir et al., (2010) shown that GA inhibits intestinal glucose absorption via interaction with membrane abundance of (SGLT1) in miceGA significantly blunted the increase in body weight, fasting plasma glucose and fasting insulin concentrations during high fat diet.

Chiang et al., 1995 & 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.

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Serum leptin of Obese Rats.

Results tabulated in table (6) illustrate the effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flaxseeds on serum leptin of obese rats. Feeding rats on high fat diet increased the mean value of serum leptin, as compared to normal rats fed on basal diet (control negative group).

Serum leptin decreased gradually with increasing the levels of mackerel fish, Arabic gum and flaxseeds. The high levels of mackerel fish, Arabic gum and flaxseeds are more effect in decreasing the mean values of serum leptin, as compared to the low levels from these materials. Treating obese rats with the high levels from the mixture of (mackerel fish, Arabic gum and flaxseeds) improved serum leptin, than that of the other treated groups.

Table (6): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on serum leptin of Obese Rats.

Groups \ Parameter		Leptin(ng/ml)
Control (-ve)		5.766 [f] ± 0.572
Control (+ve)		22.508 [a] ± 1.987
High fat diet containing	Mackerel fish PW with 14% protein.	19.485 [b c] ± 2.108
	Mackerel fish PW with 22% protein.	16.130 [d] ± 0.830
	5% Arabic gum	20.451 [b] ± 1.973
	10% Arabic gum	17.976 [c] ± 0.558
	5% flaxseeds	21.156 [a b] ± 1.854
	10% flaxseeds	18.457 [c] ± 0.503
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	14.950 [d] ± 1.415
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	11.372 [e] ± 1.208

- 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 letters similar or partially are not significant. - PW: Provided with.

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 also dietary fiber was inversely associated with leptin level in young Japanese adults **(Murakami et al., 2007 and Kuroda et al., 2010).**

Many studies suggested a strong positive correlation between blood leptin concentration, BMI and intake of dietary fiber ***(Ganji et al., 2009).***

McCullough et al. (2011) reported that consumption of flaxseed significantly increased plasma and adipose levels of alpha linolenicacide(ALA). Leptin protein levels were elevated in animals taking diet supplemented with 10 % flaxseed.

Prior studies have consistently reported higher leptin levels in women than in men **(Widjaja et al., 1997)**, women on the fish diet had leptin levels less than half those observed in men on a vegetarian diet. The fish-eating men and women had leptin levels even lower than the values observed in persons heterozygous for a frameshift mutation in the *ob* gene **(Farooqi et al., 2001)**.

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 n-3 polyunsaturated fatty acids and their antithrombotic action and modification of immunological processes **(Leaf, 1990)**.

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on kidney functions of Obese Rats.

Results in Table (7) illustrate effect of low caloric and sodium diets by using mackerel fish, Arabic gum and flaxseeds on serum (uric acid, urea nitrogen and creatinine "mg/dl") of obese rats.

Feeding rats on high fat diet increased the mean value of serum uric acid, urea nitrogen and creatinine, as compared to normal rats fed on basal diet (control negative group). Serum uric acid, urea nitrogen and creatinine decreased gradually with increasing the levels of mackerel fish, Arabic gum and flaxseeds. The high levels of mackerel fish, Arabic gum and flaxseeds are of more effect in decreasing the mean values of serum kidney functions, as compared to the low levels from these materials.

Treating obese rats group with flaxseeds led to more improvement in serum uric acid, urea nitrogen and creatinine, as compared to mackerel fish and Arabic gum groups. Treating obese rats with the high levels from the mixture of (mackerel fish, Arabic gum and flaxseeds) improved serum uric acid, urea nitrogen and creatinine, than that of the other treated groups.

Table (7): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on kidney functions of Obese Rats.

Parameters / Groups		Uric acid	Urea nitrogen	Creatinine
		mg/dl		
Control (-ve)		1.546 [e] ± 0.150	26.824 [g] ± 0.907	0.552 [f] ± 0.039
Control (+ve)		2.755 [a] ± 0.131	66.751 [a] ± 1.982	2.104 [a] ± 0.185
High fat diet containing	Mackerel fish PW with 14% protein.	2.407 [b] ± 0.071	60.110 [b] ± 2.003	1.802 [b] ± 0.186
	Mackerel fish PW with 22% protein.	1.999 [c] ± 0.081	52.846 [d] ± 1.506	1.496 [c d] ± 0.147
	5% Arabic gum	2.304 [b] ± 0.093	56.799 [c] ± 1.727	1.662 [b c] ± 0.166
	10% Arabic gum	1.856 [d] ± 0.096	49.641 [e] ± 1.243	1.332 [d e] ± 0.086
	5% flaxseeds	2.114 [c] ± 0.076	52.683 [d] ± 2.416	1.492 [c d] ± 0.114
	10% flaxseeds	1.678 [e] ± 0.049	45.374 [f] ± 1.605	1.185 [e f] ± 0.044
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds)	2.032 [c] ± 0.110	50.414 [e] ± 1.590	1.340 [d e] ± 0.171
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	1.849 [d] ± 0.116	44.310 [f] ± 1.900	1.134 [e] ± 0.102

- 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 letters similar or partially are not significant. - PW: Provided with.

Clark et al., (1995) demonstrated that flaxseed consumption decline significantly serum creatinine with 30 and 45 g. the researcher concluded that, 30 g flaxseed/day was well tolerated and conferred benefit in terms of renal function as well as inflammatory and atherogenic mechanisms important in the pathogenesis of lupus nephritis. On the other hand, **Ogborn et al., (1999)** suggested that administration of Han: SPRD-cy rats with 10% flaxseed for eight weeks from weaning had lower serum creatinine (69 vs. 81 mumol/liter, P = 0.02).

Bliss et al. (1996)investigated that supplementation with gum Arabic fiber increases fecal nitrogen excretion and lowers serum urea nitrogen concentration in chronic renal failure patients consuming a low-protein diet.**Nasir et al., (2008)**concluded that, treatment with GA resulted in moderate but significant increases of creatinine clearance and altered electrolyte excretion, i.e., effects favorable in renal insufficiency**.**

Gum Arabic (GA [Acacia senegal]) is reputed, in Arabian medicinal practices, to be useful in treating patients with chronic renal failure (CRF). GA (6%w/v and 12%w/v in drinking water for four consecutive weeks) significantly ameliorated the adverse biochemical alterations indicative of renal failure, abated the decrease in body weight and reduced the glomerular, tubular and interstitial lesions induced by adenine. The mechanism(s) of this nephroprotection is uncertain but may involve anti-oxidant and/or anti-inflammatory actions **(Ali et al., 2010).**

Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on Liver Enzymes of Obese Rats.

The effect of low caloric and sodium diets by using mackerel fish, arabic gum and flaxseeds on serum aspartate amino transferase AST, ALT and alanineamino transferase and alkaline phosphatase ALP of rats suffering from obesity presented in Table (8).

Feeding rats on high fat diet increased the mean value of serum AST, ALT and ALP, as compared to normal rats fed on basal diet (control negative group). Liver enzymes decreased gradually with increasing the levels of mackerel fish, Arabic gum and flaxseeds. The high levels of mackerel fish, Arabic gum and flaxseeds are more effect in decreasing the mean values of serum liver enzymes, as compared to the low levels from these materials. Treating obese rats with the high levels from the mixture of (mackerel fish, Arabic gum and flaxseeds) improved serum liver enzymes, than that of the other treated groups.

In this respect, **Hemmings and Song, (2005)** mentioned that flaxseed consumption conferred greeted protection against liver injury in the male than in the female suggests an involvement of the estrogenic lignan component of flaxseed. This hepatoprotection is through a flax lignan-induced increase in reduced glutathione related to a flax effect on the activity of liver gamma GT in the resting state and the maintenance of its activity in response to injury. **FaseehuddinShakir and Madhusudhan (2007)** reported that, flaxseed chutney supplemented diet could lower the serum cholesterol and as a potential source of antioxidants it could exert protection against hepatotoxic damage induced by carbon tetrachloride (CCl_4) in rats.

Gamal el-din et al., (2003) reported that Arabic gum administration dramatically reduced acetaminophen-induced hepatotoxicity as evidenced by reduced serum alanine amino transferase(ALT) and aspartate aminotransferase (AST) activities. Acetaminophen-induced hepatic lipid peroxidation was reduced significantly by Arabic gum pretreatment.

Donadi (1991) reported that, Omega-3 polyunsaturated fatty acids (PUFAs) may limit the production or action of cytokines and eicosanoids evoked by the initial or by repeated immunologic renal injury. **Friedman and Moe (2006)** reported that omega-3 fatty acids may have clinical benefits, formal recommendations encouraging omega-3 supplementation of dialysis patients are premature until long-term and adverse effects are better defined. Also **Liang et al., (2007)** reported that,fish meat protein itself did not indicate superior beneficial effects in the regression of the renal function in Imai rats as compared with casein protein.

Regarding the liver enzymes ***Ashraf and Abd-El Salam (1998)*** found that, the levels of AST and ALT significantly increased in diabetic rats than non-diabetic rats. On the other hand, ***Yasuda et al., (1997)*** indicated that dietary enrichment with Docosahexaenoic acid-rich fish oil does not enhance the elevation of serum transaminase in carbon tetrachloride CCl4-induced liver injury in mice.

Table (8): Effect of Low Caloric and Sodium Diets by Using Mackerel Fish, Arabic Gum and Flax Seeds on liver enzymes of Obese Rats

Groups \ Parameters		AST	ALT	ALP
		U/L		
Control (-ve)		64.418 ^{g}± 4.596	18.781 ^{h}± 1.230	83.062 ^{e}± 2.226
Control (+ve)		153.675 ^{a}±6.017	81.587 ^{a}± 3.811	171.581 ^{a}± 8.561
High fat diet containing	Mackerel fish PW with 14% protein.	139.816 ^{b}± 4.756	69.074 ^{bc}± 4.805	150. 525 ^{b}± 8.184
	Mackerel fish PW with 22% protein.	128.438 ^{d}± 4.764	60.541 ^{ef}± 2.384	131.418 ^{c}± 4.609
	5% Arabic gum	143.415 ^{b}± 4.467	72.395 ^{b}± 3.814	153.584 ^{b}± 8.301
	10% Arabic gum	132.675 ^{cd}± 5.105	63.384 ^{de}± 3.161	135.454 ^{c}± 5.306
	5% flaxseeds	137.466 ^{bc}± 4.838	66.039 ^{cd}± 4.190	146.172 ^{b}± 9.141
	10% flaxseeds	127.103 ^{de}± 4.444	56.887 ^{f}± 3.692	128.530 ^{c}± 4.233
	Low levels from tested materials(14%protein+5%Arabic gum+5%flaxseeds).	120.865 ^{ef}± 6.110	59.326 ^{ef}± 4.066	130.525 ^{c}± 7.755
	High levels from tested materials(22%protein+10%Arabic gum+10%flaxseeds)	117.969 ^{f}± 3.056	49.950 ^{g}± 1.939	117.341 ^{d}± 5.653

- 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 letters similar or partially are not significant. - PW: Provided with.

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تأثير الوجبات منخفضه السعرات والصوديوم باستخدام سمك الماكريل والصمغ العربي وبذور الكتان على خفض الوزن للفئران البدينه

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المستخلص العربي

تهدف هذه الدراسة الي معرفة تأثير الوجبات منخفضة السعرات والصوديوم بإستخدام سمك الماكريل، الصمغ العربي، وبذور الكتان علي (القيم الغذائية، وزن الفئران، اوزان الكبد و الكلي منسوبا كنسبة مئوية لوزن الفئران، الجلوكوز، هورمون الليبتن، مشتقات الدهون، وظائف الكبد، ووظائف الكلي) في الفئران البدينة. أستخدمت في هذه الدراسة عدد ٦٠ فأر ذكر من نوع الالبينو من فصيلة (الاسبراجو داولي)، تم تقسيمهم الي مجموعتين رئيسيتين. المجموعة الرئيسية الأولي (٦ فئران) تم تغذيتها علي غذاء أساسي يحتوى علي ١٤% بروتين واستخدمت كمجموعة ضابطة (سالبة). المجموعة الرئيسية الثانية وعددها (٥٤ فأر) تم تغذيتها لمدة ٦ أسابيع علي غذاء عالي الدهن لإحداث السمنة في الفئران. تم تقسيم الفئران البدينة للمجموعهالرئيسيهالثانيهعشوائيا الي تسع مجموعات: *المجموعة الأولي* تم تغذيتها علي غذاء عالي الدهون واستخدمت كمجموعة ضابطة ايجابية (مصابة بالسمنة). *المجموعات (الثانية والثالثة)* تم تغذيتها علي غذاء عالي الدهن منخفض الصوديوم تحتوى علي سمك الماكريل الذي يمد الغذاء بنسب ١٤% و ٢٢% بروتين، علي التوالي. *المجموعات (الرابعة والخامسة)* تم تغذيتها علي غذاء عالي الدهن منخفض الصوديوم تحتوى علي ٥% و ١٠% صمغ عربي، علي التوالي. *المجموعات (السادسة والسابعة)* تم تغذيتها علي غذاء عالي الدهن منخفض الصوديوم تحتوى علي ٥% و ١٠% بذور الكتان، علي التوالي. *المجموعات (الثامنة والتاسعة)* تم تغذيتها علي غذاء عالي الدهن منخفض الصوديوم تحتوى علي (سمك ماكريل الذي يمد الغذاء بنسبة ١٤% بروتين، ٥% صمغ عربي و ٥% بذور كتان) و (سمك ماكريل الذي يمد الغذاء بنسبة ٢٢% بروتين، ١٠% صمغ عربي و ١٠% بذور كتان)، علي التوالي. معاملة الفئران البدينة بالوجبات مرتفعة البروتين من سمك الماكريل، الصمغ العربي، بذور الكتان و خليطهم حسن من متوسط قيم المتناول من الطعام، " تناقص في النسبة المئوية لزيادة في الوزن و اوزان الكبد والكلي كنسبة مئوية لوزن الفئران"، مقارنة بالمجموعة الضابطة المصابة بالسمنة. جميع مشتقات دهون الدم (كولسترول، جلسريدات ثلاثية، كولسترول الليبوبروتينات منخفضة الكثافة والمنخفضة جدا)، ووظائف الكلي (حامض اليوريك– نيتروجين اليوريا و الكرياتينين) و انزيمات الكبد (AST, ALT and ALP) والجلوكوز وهورمون الليبتن تناقصت معنويا في كل المجموعات المختبرة، في حين حدثت زيادة معنوية في مستوى كولسترول الليبوبروتينات عالية الكثافة، مقارنة بالمجموعة الضابطة المصابة بالسمنة. المستويات المرتفعة والمنخفضة من خليط الخامات المختبرة سجلت افضل النتائج، مقارنة بالمجموعات المقارنة الاخرى.

الكلمات المفتاحية: سمك ماكريل– بذور الكتان – الصمغ العربي – الوجبات عالية الدهن – صورة دهون الدم – وظائف الكلي – انزيمات الكبد – الجلوكوز – هورمون اللبتن– خفض الوزن.