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Evaluation Anti-Obesity Activity of Psyllium Seeds Powder on Rats Fed a High Fat Diet

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ABSTRACT

Psyllium seeds are a major source of soluble and viscous gel-forming fiber that has been associated with many health benefits such as lowering blood glucose and cholesterol and improving digestive disorders. The study aimed to evaluate the effect of feeding with psyllium seeds powder in obese rats fed on a high-fat. The results indicated that feeding with a high-fat diet caused an increase in the final weight, BWG (%), feed intake, serum glucose, serum lipids, kidney and liver functions as compared negative control group (G1) as result of obesity. On the other hand, feeding with psyllium seeds powder on obese rats fed a high-fat diet significantly reduced in the final weight, BWG, feed intake and FER. Main while, serum glucose was reduced in all treated groups (G3, G4, G5 and G6) as compared with the positive control group. This reduction was ranged from 84.25 mg/dl(G3) to 76.00 mg/dl (G6) furthermore, G6 that fed on 12% psyllium seeds powder whose showed the highest decreased on TC,TG and LDL by means 134,98.25,60.35 mg/dl, respectively and highest increased in HDL by mean 55.25 mg /dl as compared with the positive control group (G2) followed by G5. All treated groups referred to improvement in kidney and liver functions as compared with the positive control group. In conclusion, data of the present study recommended that the daily consumption of psyllium seed obese patient's diets could improve serum glucose and lipid profile and promote weight loss.

Keywords: psyllium seeds, obesity, fiber, lowering glucose and lipid profile in serum.

INTRODUCTION

Obesity is a chronic metabolic disease characterized by an excess of fat stores in the body. It is a gateway to ill health and has become a major factor in disability and death, as it affects not only adults but also children and adolescents worldwide (Aktar *et al.*, 2017).

In 2016, more than 1.9 billion adults aged 18 years and older were overweight. Of these over 650 million adults were obese and in 2019, more than 38.2 million children under the age of 5 years were overweight or obese. Overweight problem is not only a problem of high-income countries, but also a problem of low- and middle-income countries particularly in urban areas. In Africa, the number of overweight children under 5 has increased by nearly 24% percent since 2000. It has been further projected that in 2020, 39 million children under the age of 5 were overweight or obese (WHO, 2021).

Obesity is a major risk factor for type 2 diabetes metabolic syndrome, cardiovascular disease (mainly heart disease and stroke), which were the leading cause of death, some cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon) and musculoskeletal disorders (Jane *et al*., 2019). Consuming a diet rich in fiber provides benefits for many of the previous diseases.) In 75 studies were used to determine the relationship between obese people and COVID-19. Pooled analyzes reported that obese people were more probably to be COVID-19 positive, >46.0% higher, for ICU admission, 74% higher, for hospitalization, 113% higher; and for mortality, 48% increase in deaths (Popkin *et al.*, 2020).

Psyllium is a widely used fiber supplement because it is reasonably cheap and better tolerated than other fiber supplements (Pal *et al.*, 2019). Psyllium is described as a short-stemmed annual herb, growing between (30- 40 cm). Many flowering buds originate from a base Plan (Jat *et al.*, 2015). There are more than 200 species of the Plantago genus. Mucilage-rich Plantago seeds are primarily acquired from Plantago Psyllium (black Psyllium) and from Plantago ovata (blond Psyllium) Mucilagein Psyllium consists of D-xylose, D-galactoronic acid, L-arabinose and other sugar traces (Saeedi *et al.*, 2010).

Psyllium (*Plantago ovata*) is member of the family Plantaginaceae. The husk and seeds of the plant are of great medicinal and commercial importance. Psyllium seeds have various medicinal characteristics as traditional medicine (Tewari *et al.*, 2014). The Chinese have used psyllium since 1500 BC for treatment of diarrhea, hemorrhoids, constipation high blood pressure and bladder problems. It was also used topically to treat skin irritations such as poison ivy reactions and insect bites and stings. North Americans and Europeans began using psyllium for cholesterol and blood glucose-lowering effects (Ashwini *et al.*, 2015). Psyllium (Plantago ovata) is a rich source of natural antioxidants, PUFAs (ω-3 and ω-6 fatty acids), essential and sulfur-rich amino acids as recommended by the FAO for human health, phenolics and flavonoids which can be used as nutrient supplements. Moreover, these compounds have several pharmaceutical applications as anti-cancer activity and natural plant ROS scavengers (Patel *et al.*, 2016).

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The current investigation was aimed to evaluate the anti-obesity activity of psyllium seeds powder on rats fed a high-fat diet (HFD).

MATERIALS AND METHODS

Psyllium seeds (Plantago Ovata), wheat flour (82% extraction), compressed yeast, and salt (sodium chloride) were purchased from local markets at Kafr El-Sheikh Governorate, Egypt in March 2021.

All chemicals analytical grade were obtained from Morgan Company, Giza, Egypt. while, kits were purchased from EL-Gomharia Co. for Chemicals and Prugs EL-Ameria, Cairo, Egypt.

Thirty six male albino rats were purchased from Experimental Animal House of Food Technology Research Institute Lab, Sakha, Agric. Research Center, and Giza, Egypt.

Methods:

Preparation of psyllium seeds powder:

Psyllium seeds were cleaned from dust by air pressure then it milled.

Biological investigations:-

Animal and treatment:

Thirty six male albino rats (150g ±5) were fed a standard diet for 7 days as an adaptation period in wire cages under the normal laboratory conditions. Vitamins and salt mixture were made according to Campbell (1961) and Hegested (1941) formula and then rats were divided into two groups. The first group (6 rats) was fed on basal diet for another 8 weeks and was considered as negative control group (-). The second group was divided into five subgroups (6 rats each). The first one of the five subgroup was continued to feed on a high-fat diet (HFD) and was considered a positive control group (+). Other four subgroups were fed on high-fat diets substituted with 3%, 6%, 9% and 12% psyllium seeds powder, respectively for 6 weeks according to the scheme shown in Table A.

Experimental diets:

The composition of experimental diets were made according to American Institute of Nutrition (AIN) 1993 G diets formula as given in Table A.

Table A. Composition of Experimental Diets (g/100g diet):

Ingredients (g/100g diet)	N	HFD	HFD (3%)	HFD (6%)	HFD (9%)	HFD (12%)
Cholic acid	0.2	0.2	0.2	0.2	0.2	0.2
Cholesterol	__	1	1	1	1	1
L-methionine	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin mixture	1	1	1	1	1	1
Mineral mixture	3.5	3.5	3.4	3.3	3.18	3.08
Cellulose	5	5	4.92	3.47	2.7	1.94
Starch	65	49	49.8	51.96	53.47	54.94
Casein	20	20	19.52	19.04	18.56	18.08
Corn oil	5	5	4.86	4.73	4.59	4.46
Coconut oil	_	15	15	15	15	15
Psyllium seeds	_	_	3	6	9	12

N: negative diet (Basel diet). HFD: high- fat diet. HFD (3%): high- fat diet substituted with 3% Psyllium seeds powder. HFD (6%): high- fat diet substituted with 6% Psyllium seeds powder. HFD (9%): high- fat diet substituted with 9% Psyllium seeds powder. HFD (12%): high- fat diet substituted with 3% Psyllium seeds powder.

After injury with obesity and at the end of the experimental period blood samples were taken from the lateral tail vein of rats. After fasting 12 hours, blood was collected by microcapillary glass tubes and centrifuged at 3000 rpm for 20 minutes to obtain the serum and it was kept frozen at (-18°C) until used according to Malhotra (2003).

Kidney, Liver, spleen and heart were removed and kept in formalin solution (10%,v/v) according to Drury and Wallington (1980).

Body weights and food intake were measured every two days all over the experimental period. The amount of diet consumed was the difference between the weight of food that rested in the feed bin (D^a) and the amount placed one day before (D). These data were then used to calculate food intake according to the following formula reported by Ennouri *et al.* (2006):

$$\textbf{Food intake (g)} = \left[\frac{D - D^a}{1}\right] \div 1$$

Where the number 1 corresponds to the number of animals in each cage.

On other hand, all rats were weighted at the beginning and the end of experiment to calculate body weight gain (BWG), relative organs weight and feed efficiency ratio (FER) according to formula of Chapman *et al.* (1959) as follow:

BWG (g) = Final Weight – Initial Weight.

FER = Gain In Body Weight (G) /Feed Intake (G).

Relative Organs Weight = Organ Weight /Animal Body Weight ×100.

Biochemical Analysis:

High density lipoprotein (HDL) and total cholesterol were determined according to Allain (1974) while, serum glucose and triglycerides (TG) were determined according to (Trinder, 1969) and (Fassati and Prencipe, 1982), respectively. VLDL and LDL were calculated according to the formula of Lee and Nieman (1996) as follows:

LDL = Total Cholesterol - (VLDL+ HDL).

VLDL = Triglycerides / 5.

Creatinin, uric acid and urea were determined according to the method of Henry (1974), While *et al.* (1970) and Malhotra (2003), respectively. Alkaline phosphatase (ALP), Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) were determined according Moss (1982), Henry (1974) and Tietz (1976), respectively.

Statistical Analysis:

Statistical analysis was carried our using SAS statistical analysis software package SAS the obtained data were presented as means ± standard deviation (SD). Statistical analysis of variance was performed using one-way ANOVA test. Duncan's multiple range tests at ($p \leq 0.05$) level was used to compare between means (SAS, 1985).

RESULTS AND DISCUSSION

The effects of feeding with psyllium seeds powder on growth parameters of normal and obese rats fed on a high-fat diet (HFD):

Data presented in Table 1 showed the effects of feeding with psyllium seeds powder on initial weight, final weight, BWG (g), BWG%, feed intake and FER of normal and obese rats fed on a high-fat diet (HFD). These results illustrated that initial weight ranged between 133g to 138.25g and it showed no significant ($p > 0.05$) differences between all groups in the primary of the experiment period, moreover, after injury with obesity the results indicated that significant higher ($p \leq 0.05$) between all experimental group (G2, G3, G4, G5 and G6) and negative control in the final weight, BWG (g), BWG%, feed intake and FER.

From the same table, it could be observed that feeding with psyllium seeds powder lowered significantly

($p \leq 0.05$) the finial weight in all treated groups (G3, G4, G5 and G6) by means (173.38, 183.10, 177.90 and 172.63g, respectively) than positive group by mean (283.58g). G6 had the highest reducing followed by G5. Data also referred that there weren't significant differences between G4 and G3 in the finial weight at the end of the experiment period. these results are in agree with Jovanovski *et al.* (2021) whose reported that viscous fiber within a calorie-restricted diet significantly improved body weight and other markers of adiposity in overweight adults and those with additional risk factors for cardiovascular disease.

On other hand, the data also recorded that BWG (g), BWG % and FER of the control positive group was higher than the control negative group due to feeding on a high-fat diet. Meanwhile, BWG (g) of treated groups (G3, G4, G5 and G6) were – 23.63, -26.85, -27.85 and -34.98g, respectively which was lower than positive control group (73.33g) due to feeding with psyllium seeds powder that promoted weight loss in all treated group. G6 that feed on 12% psyllium seeds powder recorded highest loss in BWG (g), BWG % and FER followed by G5 that feed on 9% psyllium seeds powder but G3 that feed on 3% psyllium seeds powder was the lowest group in lossing weight. Furthermore, the results showed no significant differences between all groups in, BWG (g) and BWG (%) except G6. These data are in agreement with those of El-Sherif *et al.* (2021).

On other hand, G6 and G5 that feed on psyllium seeds with 12% and 9% reduced significantly feed intake more than the control negative group (22.73g) by means (18.33 and 19.08 g), it may be due to the high content of fiber in psyllium seeds powder. These findings are in accordance with that observed by Pai and Prabhu (2019) who reported that fiber intake increases satiety and thereby reduces excess food intake and helps in weight management.

Table 1. The effects of feeding with psyllium seeds powder on feeding and growth parameters of normal and obese rats fed on a high-fat diet (HFD):

Groups Parameters	G1 (-ve)	Obese groups G2 (+ve)	G3	G4	G5	G6	LSD
The beginning of the experiment period (after injury with obesity)							
Initial weight(g)	137^{a} ±2.94	138.25^{a} ±2.36	133^{a} ±3.89	135^{a} ±3.27	134^{a} ±3.83	135^{a} ±3.56	4.73
Final weight (g)	198.13^{b} ±3.5	210.25^{a} ±2.22	207^{a} ±2.5	209.95^{a}±1.89	206^{a} ±5.74	207.6^{a} ±2.07	4.86
BWG (g)	61^{b} ±6.25	72^{a} ±1.83	74^{a} ±1.59	74.95^{a} ±2.98	72^{a} ±4.58	72.6^{a} ±2.03	5.39
BWG (%)	44.53^{b} ±5.58	52.1^{a} ±1.93	55.7^{a} ±2.77	55.58^{a} ±3.37	53.74^{a} ±3.47	35.83^{a} ±2.88	5.23
Feed intake (g)	17.01^{b} ±1.29	19.28^{ab} ±0.95	20^{a} ±1.64	19.08^{ab} ±1.33	20.13^{a} ±1.31	19^{a} ±1.16	1.93
FER	3.59^{b} ±0.52	3.81^{a} ±0.33	3.71^{a} ±0.28	3.97^{a} ±0.28	3.60^{a} ±0.13	3.85^{a} ±0.45	0.53
The end of the experiment period							
Final weight (g)	266.28^{b} ±1.53	283.58^{a}±1.42	183.38^{c}±2.85	183.1^{c} ±1.85	177.9^{d} ±1.18	172.63^{e} ±0.79	2.56
BWG (g)	61.28^{b} ±3.05	73.33^{a}±0.91	-23.63^{c}±3.79	-26.85^{c}±0.83	-27.85^{c}±4.74	-34.98^{d}±1.92	4.34
BWG (%)	44.71^{b} ±1.36	53.06^{a} ±1.51	-17.73^{c}±2.56	-19.9^{c}±0.77	-20.75^{c}±3.42	-25.90d ±1.11	2.91
Feed intake(g)	22.73^{a}±1.94	21.3^{ab}±0.77	20.25^{ab}±1.05	20.11^{ab}±1.89	19.13^{b}±1.31	18.33^{b}±1.1	2.1
FER	2.72^{b}±0.38	3.45^{a}±0.71	-1.14^{c}±0.32	-1.35^{c}±0.16	-1.46^{c}±0.20	-1.95^{d}±0.20	0.37

Means ± standard deviations with different superscript letters in the same row are significantly different at ($P \leq 0.01$).G1 = -ve control group. G2 = +ve control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder. BWG= body weight gain. FER= food efficiency ratio.

The effects of feeding with psyllium seeds powder on organs weights (g) and relative weights (%) of normal and obese rats fed on a high-fat diet (HFD):

Organ weight measurement is important to access general toxicity because any change in organ weight is a sensitive indicator of toxicity. The liver is the target organ because most toxicants enter the body via the gastrointestinal tract, and after absorption, the toxicants are carried by the hepatic portal vein to the liver. In theory, organ weight will be affected by the suppression of body weight Hadijah *et al.* (2004)

Data in Table 2 showed the effects of feeding with psyllium seeds on liver, kidney, heart and spleen weights (g) and relative weights of normal and obese rats fed on a high-fat diet (HFD). The values of weights (g) and relative weights (%) of the positive control group (+) of liver, kidney, spleen and heart were higher than the negative control group (-) except Relative Weight of kidney. these results were in harmony with those of El-Sherif *et al.* (2021).

Table 2. The effects of psyllium seeds powder on liver, kidney, heart and spleen weights (g) and relative weights (%) of normal and obese rats fed on a high-fat diet (HFD):

Rats groups	Final Body Weight (g)	Liver Weight (g)	Liver Relative Weight (%)	Kidney Weight (g)	Kidney Relative Weight (%)	Heart Weight (g)	Heart Relative Weight (%)	Spleen Weight (g)	Spleen Relative Weight (%)
G1	266.28^{b}±1.53	5.97^{b}c±0.55	2.24^{d}±0.22	1.26^{a}±0.06	0.48^{c}±0.01	0.66^{b}±0.02	0.25^{a}±0.01	0.67^{ab}±0.6	0.25^{b}±0.03
G2	283.58^{a}±1.42	7.14^{a}±0.22	2.51^{cd}±0.08	1.29^{a}±0.03	0.45c±0.02	0.73^{a}±0.02	0.26^{a}±0.01	0.74^{a}±0.3	0.26^{b}±0.01
G3	183.38^{c}±2.85	6.72^{b}±0.34	3.42^{a}±0.23	1.29^{a}±0.05	0.7^{a}±0.03	0.75^{a}±0.05	0.41^{a}±0.03	0.65^{ab}±0.5	0.35^{a}±0.02
G4	183.1^{c}±1.85	5.61^{b}c±0.42	3.06^{ab}±0.23	1.18^{b}±0.05	0.64^{b}±0.02	0.76^{a}±0.02	0.42^{a}±0.49	0.71^{ab}±0.5	0.39^{a}±0.03
G5	177.9^{d}±1.18	5.12^{c}±0.76	2.88^{bc}±0.43	1.11^{b}±0.06	0.64^{b}±0.05	0.74^{a}±0.01	0.42^{a}±0.01	0.67^{a}±0.3	0.38^{a}±0.01
G6	172.6^{e}±0.79	5.50^{b}c±0.31	3.18^{ab}±0.18	1.09^{b}±0.05	0.63^{b}±0.03	0.72^{a}±0.01	0.66^{a}±0.01	0.66^{ab}±0.5	.0.38^{a}±0.3
LSD	2.56	0.70	0.37	0.07	0.04	0.04	0.30	0.07	0.03

Means ± standard deviations with different superscript letters in the same colum are significantly different at ($P \leq 0.01$).G1 = -ve control group. G2 = +ve control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder.

The data also reported that there were no significant ($p > 0.05$) changes between all treated groups (G3, G4, G5 and G6) in the weight and relative weight of the liver, kidney, heart and spleen except the kidney weight and relative weight in group 3. Data in the same table recorded that there were non-significant differences ($p>0.05$) between groups (G3, G4, G5 and G6) and normal group (G1) in all of spleen and liver weigh obtained result are agreement with Norazmir and Ayub (2010).

The effects of feeding with psyllium seeds powder on serum blood glucose level (mg/dl) of normal and obese rats fed on a high-fat diet (HFD):

The effects of feeding with psyllium seeds powder on serum blood glucose of normal and obese rats are presented in fig. 1. After injury with obesity, it can be noticed that serum blood glucose raised significantly in all the experimental groups (G2, G3, G4, G5 and G6) by means (180.74, 180.75, 179.5, 186 and 183.5 mg/dl, respectively) as compared with control (-) group (80.5 mg/dl) but the results didn't show significant changes between control (+) group (180.74) and other treated groups (G3, G4, G5 and G6).

On the other hand, at the end of the experiment period, serum blood glucose showed that the positive control group (192.75mg/dl) had a higher ($p\leq0.05$) than the negative control group (-) (83.75mg/dl) and other treated group. Serum glucose was significantly ($p\leq0.05$) reduced by feeding with psyllium seeds powder. The best reduction was rats in G (6) by means (76.00 mg/dl) followed by G5 by means (79.5mg/dl) then in G 4 by means (82.75 mg/dl). This finding could be explained by that psyllium seeds forms a viscous gel that increases food bulk which slows the interactions of digestive enzymes with complex carbohydrates and blood glucose that Reduces peak postprandial blood glucose concentration The results were in agreement with Xiao *et al.* (2020) who demonstrated a significant reduction in fasting blood sugar and hemoglobin (HbA1c) by feeding with psyllium as a source of Water-soluble dietary fibers. Also, it is in the same way with Abutair *et al.* (2016) who found that combining soluble fiber to the diet improves glycemic response and glucose metabolism. On other hand, Hashem *et al. (*2021) reported that psyllium husk ethanolic extract (PHEE) administration alleviated the negative impact of hyperlipidemic on the serum levels of glucose, insulin, glycated hemoglobin (HbA1c) and homeostatic model assessment for insulin resistance.

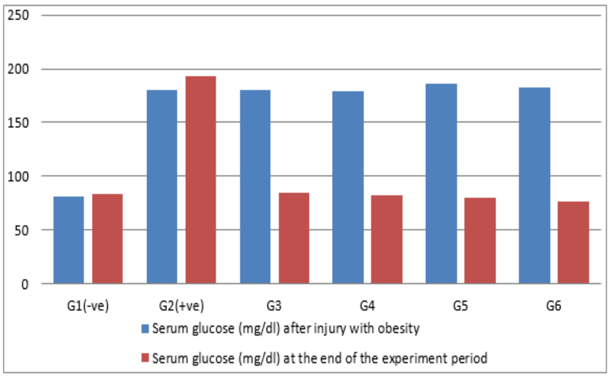

Fig. 1. The effects of feeding with psyllium seeds powder on serum blood glucose level (mg/dl) of normal and obese rats fed on a high-fat diet (HFD):

G1 = -ve control group. G2 = +ve control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder.

The effects of feeding with psyllium seeds powder on TG, TC, LDL ,HDL and VLDL of normal and obese rats fed on a high-fat diet (HFD):

Data in Table (3) showed that the levels of total cholesterol (TC), triglyceride (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) in the negative control group (-) and obese rats fed on a high-fat diet (HFD) with psyllium seeds powder. After injury of obesity, TC, TG, LDL and VLDL values of the negative control group (-) showed significant differences ($p\leq0.05$) compared with all experimental groups (G2, G3, G4, G5 and G6). On the other hand, obese groups showed a significant ($p\leq0.05$) decreased in HDL value as compared with the control (-) group (49.5mg/dl).

Table 3. The effects of feeding with psyllium seeds powder on TG, TC, LDL, HDL and VLDL of normal and obese rats fed on a high-fat diet (HFD):

Groups / Parameters	G1 (-ve)	obese groups					LSD
		G2 (+ve)	G3	G4	G5	G6	
The beginning of the experiment period (after injury with obesity)							
T C (mg/dl)	$114.25^{b}\pm2.99$	$260.5^{a}\pm3.11$	$262.5^{a}\pm2.38$	$257.75^{a}\pm1.70$	$263.25^{a}\pm3.59$	$260.5^{a}\pm3.70$	4.45
TG(mg/dl)	$90.25^{c}\pm2.22$	$140^{ab}\pm1.82$	$142.75^{a}\pm0.96$	$138.25^{b}\pm1.71$	$141.5^{ab}\pm1.29$	$139^{b}\pm2.58$	2.74
HDL (mg/dl)	49.5a±2.38	$30.25^{b}\pm2.26$	$29.75^{b}\pm1.89$	$28.25^{b}\pm0.81$	$28.00^{b}\pm1.73$	$27.5^{b}\pm1.71$	2.53
LDL (mg/dl)	$46.7^{b}\pm4.26$	$202.25^{a}\pm3.86$	$204.2^{a}\pm2.72$	$202.1^{a}\pm1.48$	$207.45^{a}\pm4.8$	$204.45^{a}\pm1.86$	5.04
VLDL (mg/dl)	$18.05^{c}\pm4.40$	$27.85^{ab}\pm5.50$	$28.55^{a}\pm0.19$	$27.65^{b}\pm0.34$	$28.3^{ab}\pm0.26$	$27.8^{ab}\pm0.52$	0.6
The end of the experiment period							
TC(mg/dl)	$122^{f}\pm6.68$	$280.5^{a}\pm4.04$	$200^{b}\pm2.16$	$173^{c}\pm2.94$	$156.5^{d}\pm1.29$	$134^{e}\pm2.94$	5.58
T G (mg/dl)	$94.25^{f}\pm1.29$	$160.75^{a}\pm2.22$	$130.5^{b}\pm1.29$	$119.75^{c}\pm2.63$	$105.25^{d}\pm2.5$	$98.25^{e}\pm2.22$	3.11
HDL(mg/dl)	$53.25^{b}\pm0.96$	$28.25^{f}\pm1.26$	$41.25^{e}\pm0.96$	$47.5^{d}\pm1.29$	$50.25^{c}\pm2.06$	$55.25^{a}\pm0.96$	1.94
LDL (mg/dl)	$49.85^{f}\pm7.35$	$220.1^{a}\pm4.38$	$132.85^{b}\pm2.66$	$101.75^{c}\pm2.34$	$85.2^{d}\pm3.31$	$60.35^{e}\pm3.64$	6.36
VLDL(mg/dl)	$18.9^{f}\pm0.26$	$32.15^{a}\pm0.44$	$26.1^{b}\pm0.26$	$23.75^{c}\pm0.53$	$21.05^{d}\pm0.5$	$19.65^{e}\pm0.44$	0.62

Means ± standard deviations with different superscript letters in the same row are significantly different at (P≤ 0.05).TC = total cholesterol. TG = triglyceride. HDL = high density lipoprotein. LDL = low density lipoprotein. VLDL = very low-density lipoprotein. G1 = negative control group. G2 = positive control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder.

On the other hand, at the end of the experiment period, the results displayed that the values of the negative control group(-) of TC, TC, LDL and VLDL were (122, 94.25, 49.85 and 18.9, respectively) which showed significant differences ($p\leq0.05$) with control positive group(+) which were 280.5, 160.75, 220.2 and 32.15, respectively. Feeding of psyllium seeds powder reduced the TG, TC, VLDL, LDL levels but still higher than the control negative group. The best reducing recorded in G 6 (134, 98.25, 60.35 and 19.65 mg/dl, respectively) followed by G5 (156.5, 105.25, 85.2 and 21.05mg/dl, respectively). But the lowest reducing recorded in G3 (200, 130.5, 132.85, 26.1mg/dl, respectively). This data is in agreement with El-Sherif *et al.* (2021). Hashem *et al.* (2021) showed that treating hyperlipidemic rats with psyllium husk ethanolic extract (PHEE) showed a decrease in the total serum lipids, triglyceride (TG), total cholesterol (TC).

Otherwise, HDL values had the opposite trend. The results indicated that supplementation with psyllium seeds powder increased HDL values in all traded groups. The highest increased was in G6 (55.25mg/dl) which was higher than the control negative group (53.25mg/dl) followed by G5 (50.25mg/dl). These findings could be explained by that when psyllium seeds absorb water from the intestinal, they form a great viscous gel. It binds to bile acids and loses its functions, which prompts the liver to synthesize more bile acids and excrete more cholesterol and LDL-cholesterol, which reduces their concentration in the blood without affecting HDL-cholesterol level (good cholesterol). Such findings are in accordance with that observed by González *et al.* (2021) who showed obesity can lead children and adolescents to an increased cardiovascular disease (CVD) risk. A diet supplemented with Plantago psyllium has been shown to be effective in reducing LDL, TG, TC and VLDL but it increases

The effects of feeding with psyllium seeds powder on liver function (ALT, AST, ALP and AST/ALT) of normal and obese rats fed on a high-fat diet (HFD):

Table (4) presents the effects of feeding with psyllium seeds powder on AST, ALT and ALP in normal and obese rats fed on a high-fat diet (HFD). After injury with obesity, the negative control group (-) had lower ($P \leq 0.05$) ALT, AST and ALP activities than the positive control group (+). While AST, ALT and ALP values increased on all obese groups as compared with the negative control group (-) it may be caused by obesity.

On the other hand, at the end of the experiment period, the result showed that the positive control group (+) was higher than the negative control group (-) in AST, ALT and ALP. While, all groups that feed with psyllium seeds powder had lower ($P \leq 0.05$) ALT, AST and ALP activities than the positive control group (+) by different rates. Furthermore, G6 that feed on 12% psyllium seeds was more effective ($P \leq 0.05$) in reducing AST, ALT and ALP activities by means 53, 35.3 and 100.85 U/L, respectively but still higher than the values of the negative control group (-) except AST value followed by G5 with means 69.18, 36.6 and 110.35 U/L, respectively but G3 had the lowest effect in reducing liver function by means 86, 45.35 and 125.43 U/L, respectively. The results are in the same line with those of Ismael and Shehata (2020) who showed that plantago psyllium seed is a valuable medicinal plant with plenty of biologically effective compounds. Daily consumption of psyllium seed for 28 days caused significant changes in liver enzymes levels (ALT and AST) in both the control and treatment groups. Also, the results were supported by those of El-Sherif *et al.* (2021).

As for AST/ALT, data recorded non-significant differences between G3, G4 and G5 but it recorded significant differences with the control (-) group and all treated groups (G3, G4, G5 and G6). Rocha *et al.* (2007) showed that receiving 10g/day of oral soluble fibers during 3 months caused normal liver enzymes (AST, ALT and GGT) in obese patients with nonalcoholic fatty liver disease.

Table 4. The effects of feeding with psyllium seeds powder on liver function (ALT, AST, ALP and AST/ALT) of normal and obese rats fed on a high-fat diet (HFD):

Groups	G1 (-ve)	Obese groups					LSD
Parameters		G2 (+ve)	G3	G4	G5	G6	
The beginning of the experiment period (after injury with obesity)							
AST U/L	50^{e}±1.14	91.25^{bc}±1.228	95^{a}±1.1	93^{b}±0.82	90.1^{c} 3±1.37	87.15^{d}±1.45	1.80
ALT U/L	30.33^{d}±0.98	55.35^{b}±1.65	54.38^{b}±0.92	59.4^{a}±1.16	52.45^{c}±1.17	51.38^{c}±1.28	1.81
AST/ALT U/L	1.64 ^{ab}±0.04	1.65^{ab}±0.06	1.75^{a}±0.05	1.56^{b}±0.03	1.72^{a}±0.05	1.70^{a}±0.06	0.07
ALP U/L	93.48^{e}±1.09	140.43^{bc}±1.89	136.43^{d}±1.30	144.48^{a}±1.11	142.4^{ab}±1.87	138.58^{c}±1.00	2.12
The end of the experiment period							
AST U/L	55.65^{e}±2.10	124.1^{a}±1.20	86^{b}±2.51	80^{c}±2.34	69.18^{d}±1.45	53^{e}±1.28	3.31
ALT U/L	33.73^{e}±1.23	71.6^{a}±1.03	45.35^{b}±1.95	41.28^{c}±1.08	36.6^{d}±0.70	35.3^{de}±1.40	1.92
AST/ALT U/L	1.64^{b}±0.11	1.73^{b}±0.03	1.91^{a}±0.08	1.94^{a}±0.07	1.89^{a}±0.03	1.51^{c}±0.09	0.11
ALP U/L	96.18^{c}±1.17	156.33^{a}±0.63	125.43^{b}±0.63	119.5^{c}±1.49	110.35^{d}±6.05	100.85^{e}±4.45	4.73

Means ± standard deviations with different superscript letters in the same row are significantly different at ($P \leq 0.05$). AST = aspartate aminotransferase. ALT = alanine aminotransferase. ALP = alkaline phosphatase. G1 = negative control group. G2 = positive control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder.

The effects of feeding with psyllium seeds powder on uric acid, urea and creatinine of normal and obese rats fed on a high-fat diet (HFD):

Chronic kidney disease is considered an inflammatory state. high dietary total fiber intake is associated with lowering the risk of inflammation and mortality in kidney disease Krishnamurthy *et al.* (2012).

The effects of feeding with psyllium seeds powder on uric acid, urea and creatinine of normal and obese rats fed on a high-fat diet (HFD) are given in Table 5. Data illustrated that after injury with obesity, uric acid, urea and creatinine increased in obese groups (G2, G3, G4, G5 and G 6) compared with the normal group (-).

Data in the same table summarized that at the end of the experiment period, the positive control group (+) was still higher ($p \leq 0.05$) in uric acid, urea and creatinine than the negative control group (-). But feeding with psyllium seeds led to reduce the values.

On the other hand, the results reported that uric acid content showed significant change ($p \leq 0.05$) between G1, G2, G3 and G6 by means (1.41, 1.95, 1.87 and 1.98mg/dl, respectively) while it displayed non-significant ($p > 0.05$) between G4 and G5 by means (1.88 and 1.93mg/dl). These findings are in harmony with Ebadollahi-Natanzi and Arabrahmatipour (2020) who reported that psyllium seeds may be effective in reducing serum uric acid levels in hyperuricemia patients, and major adverse effects are not expected to occur.

Furthermore, G3, G4, G5 and G6 didn't show a significant difference ($p \leq 0.05$) between them in urea by means (36.5, 35.75, 35.75 and 33.75 mg/dl, respectively) but showed significant lower ($p \leq 0.05$) as compared with positive control group by means (40.25mg/dl). These results were supported by El-Sherif *et al.* (2021).

Creatinine values were in the same way as urea values which didn't show significant differences between the negative control group (-) and all treated groups (G3, G4, G 5and G6). G6 had the nearest values to the normal group in uric acid, urea and creatinine followed by G5. Data agree with these of Chiavaroli *et al.* (2015) who demonstrated that dietary fiber supplementation significantly reduced serum urea and creatinine levels.

Table 5. The effects of feeding with psyllium seeds powder on urea, uric acid, and creatinine of normal and obese rats fed on a high-fat diet (HFD):

Groups / Parameters	G1 (-ve)	Obese groups: G2 (+ve)	G3	G4	G5	G6	LSD
The beginning of the experiment period (after injury with obesity)							
Uric acid (mg/dl)	$1.41^{b}\pm0.14$	$1.95^{a}\pm0.03$	$1.87^{a}\pm0.02$	$1.88^{a}\pm0.01$	$1.93^{a}\pm0.01$	$1.98^{a}\pm0.01$	0.09
Urea (mg/dl)	$27.25^{b}\pm2.22$	$36.5^{a}\pm1.91$	$37.25^{a}\pm1.71$	$36.25^{a}\pm0.96$	$36.5^{b}\pm0.91$	$33.75^{b}\pm0.96$	2.5
creatinine (mg/dl)	$1.07^{a}\pm0.09$	$1.1^{a}\pm0.07$	$1.07^{a}\pm0.04$	$0.83^{a}\pm0.46$	$1.15^{a}\pm0.06$	$1.11^{a}\pm0.07$	0.29
The end of the experiment period							
Uric acid (mg/dl)	$1.45^{e}\pm0.02$	$2.13^{a}\pm0.09$	$1.73^{b}\pm0.03$	$1.65^{c}\pm0.03$	$1.63^{c}\pm0.02$	$1.55^{d}\pm0.02$	0.07
Urea(mg/dl)	$30.5^{c}\pm1.29$	$40.25^{a}\pm2.87$	$36.5^{b}\pm1.73$	$35.75^{b}\pm2.06$	$35.75^{b}\pm1.73$	$33.75^{b}\pm0.96$	2.78
Creatinine(mg/dl)	$1.1^{ab}\pm0.07$	$1.22^{a}\pm0.10$	$1.04^{b}\pm0.03$	$1.03^{b}\pm0.10$	$1.12^{ab}\pm0.07$	$1.04^{b}\pm0.08$	0.12

Means ± standard deviations with different superscript letters in the same row are significantly different at (P≤ 0.01). G1 = -ve control group. G2 = +ve control group. G3 = feed on a high-fat diet with 3% psyllium seeds powder. G4 = feed on a high-fat diet with 6% psyllium seeds powder.G5 = feed on a high-fat diet with 9% psyllium seeds powder. G6 = feed on a high-fat diet with 12% psyllium seeds powder.

CONCLUSION

Daily administration of psyllium seeds powder promoted weight loss and reduced serum glucose, TC, TG, LDL and VLDL while, increased HDL and improve liver and kidney function of obese rats compared with normal rats. obtained result suggested that psyllium seeds considered apotention agent for obesity treatment and considered as a new source of bioactive and functional food.

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تقييم النشاط المضاد للسمنة من مسحوق بذور القطونه على الفئران التي غذت نظامًا غذائيًا عالي الدهون

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تعتبر بذور القطونه مصدرًا رئيسيًا للألياف القابلة للذوبان واللزجة المكونة للهلام والتي ارتبطت بالعديد من الفوائد الصحية مثل خفض نسبة الجلوكوز والكوليسترول في الدم وتحسين اضطرابات الجهاز الهضمي ، وقد هدفت الدراسة إلى تقييم تأثير التغذية علي مسحوق بذور القطونه في الفئران البدينة التي تتغذى على نظام غذائي عالي الدهون ، تم تقسيم ستة وثلاثين من ذكور الفئران إلى ست مجموعات متساوية ،وتم الاحتفاظ بواحدة كمجموعة ضابطة سالبة ، بينما تم تغذيه المجموعات الخمس الأخرى على نظام غذائي عالي الدهون لمدة 8 أسابيع للاصابه بالسمنة، ، وتم الاحتفاظ بواحدة كمجموعة ضابطة موجبه. بينما تغذت المجموعات الأربع الأخرى بمسحوق بذور القطونه بنسب استبدال 3 و 6 و 9 و 12٪ من النظام الغذائي القياسى لمدة 6 أسابيع ، وأشارت النتائج إلى أن التغذية بنظام غذائي عالي الدهون في م2 وم3 و م4 و م5 و م6 تسبب في زيادة الوزن النهائي والوزن المكتسب ونسبته المئويه والكمية الماخوذه من الغذاء ونسبه الجلوكوز والدهون في الدم وزياده نشاط انزيمات الكبد والكلى بالمقارنة بالمجموعة الضابطه السالبة (م1) وذلك نتيجة للاصابه بالسمنة. ومن ناحية أخرى ، فإن الفئران البدينة التي تغذت على نظام غذائي غني بالدهون ومسحوق بذور القطونه اظهرت انخفاض بشكل كبير في الوزن النهائي والوزن المكتسب ونسبته المئويه وكميه الماخوذ من الغذاء ومعدل الاستفاده من الغذاء ، انخفض ايضا مستوى الجلوكوز في الدم في جميع المجموعات المعالجة (م3 و م4 و م5 و م6) بالمقارنة بالمجموعه الضابطه الموجبه. ويتراوح هذا الانخفاض من 84.25 مجم / ديسيلتر(م3) إلى 76.00 مجم / ديسيلتر (م6) .علاوة على ذلك ، فان م6 التى تغذت على 12٪ من مسحوق بذور القطونه أظهرت أعلى انخفاض في قيمه كل من الكوليستيرول الكلى و الدهون الثلاثيه الكليه والليبوبروتينات منخفضه الكثافه بمتوسطات 134، 98.25، 60.35 مجم/ ديسيلترعلى التوالي وسجل ايضا أعلى زيادة في الليبوبروتينات مرتفعه الكثافه بمتوسط 55.25 مجم / ديسيلتر بالمقارنة بالمجموعه الضابطه الموجبه (م2) تليها م5. ووجدت النتائج أيضا أن جميع المجموعات المعالجة أشارت إلى تحسن في وظائف الكبد والكلى وتحسن في التغيرات الباثولوجيه المرضيه في قطاعات الكلى والكبد بالمقارنة بالمجموعه الضابطه الموجبه (م2). وفي الختام ، أوصت الدراسة بالاستهلاك اليومي لبذور القطونه من وجبات المرضى الذين يعانون من السمنة المفرطة والتى يمكن أن تحسن مستوى الجلوكوز والدهون في الدم وتعزز فقدان الوزن.

الكلمات المفتاحيه: بذور القطونه ، السمنه ، الالياف ، خفض جلوكوز ودهون الدم.