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Biochemical and Biological Studies on Tomato and Eggplant Peels as Added for Amelioration of Obesity and Diabetes in Albino Rats

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Abstract:

This research investigated the potential health effects of certain peels on obese and diabetic rats. Fifty-five albino rats (150±10g) were divided into three groups; the first (5 rats) was a negative control. The second 25 rats were fed a high-fat diet for 28 days to induce obesity. Then they were divided into five groups (5 rats each); one was kept as a positive control group, while the other four were given powdered tomato peels 2%; tomato peels 5%; eggplant peels 2%, and eggplant peels 5%. 2% tomato peels; 5% tomato peels; 2% eggplant peels; 5% eggplant peels. The third main group (25 rats) was injected with alloxan to induce diabetes, then divided into five groups (5 rats each); one was a positive control group. In contrast, the left four groups were given powdered tomato peels 2%; tomato peels 5%; eggplant peels 2%, and eggplant peel 5%. The treatment lasted for 28 days. According to the findings, eggplant peels 5 percent reduced total cholesterol by 147.08±2.44 and 138.51±1.24 mg/dl in obesity and diabetes mellitus, respectively. For obesity and diabetes mellitus, eggplant peels 5% recorded the highest effects of improving liver and kidney function enzyme ratios. Meanwhile, the findings suggested that tomato peels (2%), tomato peels (5%), eggplant peels (2%), and eggplant peels (5%) might be utilized to treat obesity and diabetes mellitus. In conclusion, eggplant and tomato peels are beneficial to the health of obese and diabetic people.

***Key words**: Overweight, Hyperglycemia, Kidney, Tomato, Eggplant*

Introduction

Obesity is a chronic metabolic disorder that affects both adults and children throughout the world. It has risen to become one of the most common causes of death. The body mass index (BMI) is still used to categories overweight and obesity today. The measurement of body composition is strongly suggested because decreasing muscle mass is common throughout the BMI range. It is also necessary for tracking the progress of weight loss, which is an important aspect of any efficient anti-obesity treatment. Weight loss can be done through a variety of methods, including lifestyle changes (diet and exercise), medication, and bariatric surgery. However, not all of these strategies are appropriate for all patients, and any additional requirements should be taken into account (1). Obesity is linked to a number of health problems, including diabetes, heart disease, obstructive sleep apnea, and cancer (2).

Because of its high moisture content and low-calorie value, eggplant or brinjal (*Solanum melongena*, L.) fruit is popular as a diet food vegetable. It is, nevertheless, a good source of antioxidants and phytonutrients. Because of its greater antioxidant, protein, and sugar content, eggplant is a nutritionally beneficial vegetable (3). Eggplant is the fifth most important solanaceous crop in terms of economic importance (4).

Tomatoes (*Solanum lycopersicum*) are high in vitamin C, potassium, folic acid, and carotenoids such as lycopene (5). Tomato peel is high in antioxidants like flavonoids, phenolic acids, ascorbic acid, and minerals, as well as vital amino acids and fatty acids (Ca, Cu, Mn, Zn, and Se) (6). Tomato juice lowers oxidative stress in overweight (and possibly obese) females, which may help to avoid obesity-related disorders and improve overall health (7). According to Mauara *et al*., (8), eggplant (*Solanum melongena*, L.) flour (EF) improved antioxidant status in obese women by increasing antioxidant capacity while also reducing fat mass. EF appears as a functional meal that can be utilized as an adjunct to obesity treatment.

Tomato is associated with a reduced risk of diabetes. Tomato containing diverse anti-inflammatory compounds ameliorates chronic inflammation in obese adipose tissue (9). According to Nawwan *et al.*, (10) the eggplant fruit diet informs a nutritional and therapeutic approach for the prevention and treatment of type 2 diabetes mellitus T2DM. The purpose of this study was to see if increasing anthocyanin pigment in (eggplant peels) and lycopene pigment in (tomato peels) by 2% and 5% per day may reduce obesity and diabetes rates. Obese rats will be fed a high fat diet (10 percent fat in the form of animal fat) and diabetic rats will be injected with aloxan. Effects of the peels indicated above on body weight increase, feed intake, feed efficiency ratio, and atherogenic index. Effects of peel feeding on blood Aspartate amino transferase (AST), Alanine amino transferase (ALT), and Alkaline phosphatase (ALP). Glutamic oxaloacetate transaminase (GOT), Glutamic pyruvic transaminase (GPT), and GOT/GPT are blood antioxidant enzymes that are improved by peels. The lipid profile is affected by 2% and 5% tomato and eggplant peels, respectively (TC, TG, HDLc, LDLc and VLDLc). Effects of various therapies on the renal function of obese and diabetic rats.

Materials and Methods:

Plants: Tomato and eggplant were collected from the local market of Shiben El-Kom, Menoufia, Egypt in January.

Preparation of tomato peel and eggplant peel powder:

Fresh tomatoes and eggplant were purchased at a nearby store. They were carefully washed under running water, then dried in an air oven at 50°C and ground into a fine powder using a mill **(11)**.

Basal Diet:

Casein, vitamins, minerals, cellulose, choline chloride, methionine, ethylene glycol, and ammonium chloride were obtained from El-Gomhoryia Company for Trading Drugs and Medical Instruments.

Animals:

The work carried out at Faculty of Home Economic, Menoufia University, Egypt. Fifty-five (55) male albino rats, Sprague Dawley strain, were fed a basal standard diet for 7 days as an adaptation period, this diet was formulated according to, the intial weight of albino Rats 150±10 g and the intial weight after obesity 260±10g. The salt mixtures and vitamin mixtures were prepared according to Reeves *et al.* (12) and Hegsted *et al.* (13), respectively. The rats were kept in wire cages in a typical laboratory setting. To reduce feed loss and contamination, the meals were given to rats in special feed containers. Rats were also given water via a glass tube that protruded through wire cages from inverted bottles on one side of the cage. The food and water provided were inspected on a daily basis.

Induction of obesity in rats:

To obtain obese rats fed on the basal diet added to it saturated fat (Sheep tail fat 20%) in 28 days **(14)**.

Induction of diabetic in rats:

Alloxan was obtained from El-Gomhoria Company for Chemicals, Drugs of Medical Equipment's, Cairo, Egypt. Diabetes was induced in overnight fasted rats by a single intraperitoneal injection of freshly prepared alloxan monohydrate in normal saline (150 mg/kg body weight) according to the method described by Desai and Bhide, (14).

Experimental design:

After adaptation period, rats were distributed into three main groups, the first main group (5 rats) kept as negative control group. The second main group (25 rats) fed on high fat diet for obesity induction, then divided into five groups (5 rats each), one of them kept as positive control group, while the left four groups were given as powdered tomato peels 2%, tomato peels 5%, eggplant peels 2% & eggplant peels 5% from basal diet. The third main group (25 rat) injected with alloxan to induce diabetic rats, then divided into five groups (5 rats each), one of them kept as positive control group, while the left four groups were given as powdered tomato peels 2%, tomato peels 5%, eggplant peels 2% & eggplant peels 5%.

Groups as follow:

Group (1): Rats fed on basal diet only as a control negative group.
Group (2): Obese rats fed on the basal diet only after during obesity for 28 days fed on high fat diet and used as a positive control.
Group (3): Obese rats fed on basal diet with 2% (tomato peels) powders.
Group (4): Obese rats fed on basal diet with 5% (tomato peels) powders.
Group (5): Obese rats fed on basal diet with 2% (eggplant peels) powders.
Group (6): Obese rats fed on basal diet with 5% (eggplant peels) powders.
Group (7): Diabetic rats fed on basal diet only and used as a positive control group
Group (8): Diabetic rats fed on basal diet with 2% (tomato peels) powders.
Group (9): Diabetic rats fed on basal diet with 5% (tomato peels) powders.
Group (10): Diabetic rats fed on basal diet with 2% (eggplant peels) powders.
Group (11): Diabetic rats fed on basal diet with 5% (eggplant peels) powders.
The body weight estimated weekly and feed intake was recorded daily.
Feeding and growth performance were carried out by determination of daily food intake, body weight gain and feed efficiency ratio (FER) according to **Chapman *et al*., (15)** using the following formulas:

BWG (g) =Final weight- Initial weight

$$\textbf{FER} = \frac{\text{Gain in Body weight (g)}}{\text{Food intake (g)}}$$

Blood sampling:

Blood samples were taken from the retro orbital vein in the beginning and the hepatic portal vein at the end of each trial after a 12-hour fast. Blood samples were collected into dry, clean centrifuge glass tubes and allowed to clot for 28 minutes in a water bath (37^{o}C), after which they were centrifuged for 10 minutes at 4000 rpm to separate the serum, which was carefully aspirated, transferred to a clean cuvette tube, and stored frozen at -20^{o}C until analysis according to method described by Schermers (16).

Biochemical analysis:

Lipoprotein fractions

Enzymatic determined of plasma glucose was carried out calorimetrically according to the method of Tinder, (17). Serum total cholesterol was determined according to the colorimetric method described by Thomas (18). Serum triglycerides was determined by enzymatic method using kits according to the Young (19), Fossati and Principle (20). HDL-c was determined according to the method described by Friedwaid (21) and Grodon and Amer (22). Serum VLDL and LDL-c cholesterol were calculated according to the method of Lee and Nieman (23). VLDL-c (mg/dl) was calculated as (triglycerides/5). LDL-c (mg/dl) was calculated as (total cholesterol – HDL-c – VLDL-c.).

Liver functions

Determination of serum GPT was carried out according to the method of Clinica Chimica Acta (24). Determination of serum GOT was carried out according to the method of Hafkenscheid (25). Determination of serum ALP was carried out according the method of Moss (26).

Kidney functions

Urea was determined by enzymatic method according to Patton and Crouch (27). Serum creatinine was determined according to the method described by Henry (28). Serum uric acid was determined calorimetrically according to the method of Barham and Tinder (29). Enzymatic determined of plasma glucose was carried out calorimetrically according to the method of Tinder (30).

Statistical analysis:

The data were statistically analyzed using a computerized program by one-way ANOVA. The results are presented as mean ± SD. Differences between treatments at $P \leq 0.05$ were considered significant (31).

Conflict of interest

The authors state that the publishing of this work does not create a conflict of interest for them. This article is based on a PhD thesis that was submitted to Menoufia University's Department of Nutrition and Food Science, Faculty of Home Economics, Shibin El-Kom, Egypt.

Results and Discussion

Table 1 shows that all rat groups fed with tomato and eggplant peels (2&5%) had significantly lower body weight gain (BWG), food intake (FI), and feed efficiency ratio (FER) than the positive control. The significant decrease in BWG for group 6 (5% eggplant peels) was 0.81(g/d/rat), compared to 1.44(g/d/rat) for the positive control. In addition, as compared to the positive control, rats treated with tomato peels 2 percent had a significant increase in FI, reaching 21.82 (g/d/rat) and rats treated with eggplant peels 2.5 percent had a significant increase in FI, reaching 21.95 (g/d/rat). On the same table, the results showed that rats given eggplant peels (5%) had a much lower FER (0.035) than the positive control (0.059). Kwon *et al.*, (32) reported a similar finding, claiming that tomato vinegar beverage (TVB) decreased fat accumulation and insulin resistance in obese mice fed a high-fat diet (HFD). These findings are accompanied by those of Mauara *et al.*, (33), who found that eggplant (*Solanum melongena,* L.) flour improved antioxidant status in obese women by increasing antioxidant capacity, lowering fat mass, and emerging as a functional food to be used as an adjuvant in the treatment of obesity.

Table (1): Effect of tomato peels and eggplant peels on body weight gain (BWG), food intake (FI) and feed Efficiency ratio (FER) of obese rats at the end study

Parameter Groups	BWG (g/day/r) (Mean ± SD)	Food intake (g/day/r) (Mean ± SD)	FER (Mean ± SD)
G1: Control –ve	0.80e ±0.009	23.74b ±0.007	0.034e ±0.0009
G2: Control +ve	1.44a ±0.004	24.35a ±0.002	0.059a ±0.0005
G3: Tomato peel (2%)	0.96b ±0.008	21.82f ±0.009	0.044b ±0.0001
G4: Tomato peel (5%)	0.85d ±0.005	22.97d ±0.001	0.037d ±0.0004
G5: Eggplant peel (2%)	0.90c ±0.001	21.95e ±0.006	0.041c ±0.0008
G6: Eggplant peel (5%)	0.81e ±0.007	23.14c ±0.008	0.035e ±0.0003
LSD	0.01	0.01	0.001

Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05).%Change of (+ve) control group.*

Table (2) shows the serum glucose levels of rats fed with tomato and eggplant peels at various amounts. When compared to positive control groups, treatment with tomato peel or eggplant peel resulted in a significant ($P \leq 0.05$) reduction in serum glucose level. It's obvious from the table that increasing the concentration of tomato and eggplant peels lowers serum glucose levels. In addition, the table revealed that eggplant peels have a better influence on serum glucose levels than tomato peels. According to the findings, eggplant peels at various levels of 5% showed significantly reduced serum glucose levels ($P \leq 0.05$) than the negative control group. According to Nwanna *et al.* (34) eggplant lowers blood sugar levels. Tomato extract was also beneficial in lowering blood glucose, according to Aborehab *et al.* (35) and could be used as a pharmacological therapy for obesity. This could be due to bioactive chemicals found in both types of peel.

Table (2): Effect of tomato peels and eggplant peels on serum glucose (mg/dl) of obese rats

Groups	Glucose (mg/dl) Mean ± SD
G1: Control –ve	131.31e ± 1.15
G2: Control +ve	187.24a ± 1.26
G3: Tomato peel (2%)	155.43b ± 1.42
G4: Tomato peel (5%)	152.21c ± 0.25
G5: Eggplant peel (2%)	150.06d ± 0.38
G6: Eggplant peel (5%)	147.10e ± 1.07
LSD	1.83

Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05).%Change of (+ve) control group.*

The table shows that the eggplant peels 5% group significantly increased HDL-c levels while decreasing VLDL-c, triglyceride, and cholesterol levels when compared to the tomato peels group (p 0.05). It was found that giving rats a high fat diet supplemented with tomato and eggplant peels (2&5%) at varied levels considerably ($p \leq 0.05$) decreased serum levels of cholesterol, LDL-c, VLDL-c, and triglyceride while significantly (p 0.05) increasing serum HDL-c. Obesity increased TC, TG, VLDL-c, and LDL-c, but lowered HDL-c, but consuming tomato and eggplant peels did the opposite, especially for the final diet. Abdel-Magied *et al.* (36) and Ni Kadek *et al.* (37) found similar results using eggplant and tomato peels, respectively.

The lipoprotein fractions in the serum of male rats given with tomato (2&5%) and eggplant (2%) peels at various levels were determined, and the results are displayed in table (3). When compared to the positive control group, treatment with tomato and eggplant peels decreased serum very low-density lipoprotein (VLDL-c), low-density lipoprotein (LDL-c), triglyceride (TG), and cholesterol while increasing high-density lipoprotein (HDL-c). The table shows that increasing the concentrations of tomato peels or eggplant peels results in a significant ($p \leq 0.05$) reduction in blood VLDL-c, LDL-c, triglyceride, and cholesterol. In addition, the table demonstrated that eggplant peels have a greater impact on HDL-c levels than tomato peels.

Table (3): Effect of tomato peels and eggplant peels on serum lipid profile in obese rats at the end experimental period

Parameter Groups	TC (mg\dl) Mean ± SD	TG (mg\dl) Mean ± SD	HDL(mg/dl) Mean ± SD	LD(mg/dl) Mean ± SD	VLDL(mg/dl) Mean ± SD
G1: Control –ve	125.7e ± 2.21	60.07d ± 1.25	61.64a ±0.26	52.08f ± 1.19	12.01d ±0.25
G2: Control +ve	240.0a ± 2.85	110.74a ±1.68	38.13f ±0.22	179.7a ± 2.45	22.15a ±0.63
G3: Tomato peel 2%	180.1b ±2.68	90.18b ± 1.59	41.38e ±0.56	120.98b ±1.62	18.04b ±0.55
G4: Tomato peel 5%	159.3c ± 2.76	85.46c ± 1.81	44.21d ± 0.09	98.02c ±1.48	17.09c ±0.42
G5: Eggplant peel 2%	156.4c ± 1.13	89.31b ± 1.73	47.35c ± 0.62	91.21d ±1.68	17.88b ±0.09
G6: Eggplant peel 5%	147.1b ±2.44	83.84c ± 1.47	50.32b ± 0.82	79.99e±1.92	16.77c ±0.09
LSD	4.30	2.85	0.89	3.14	0.71

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

The effects of varied quantities of tomato and eggplant peels on uric acid, creatinine, and urea in rats fed a high fat diet were evaluated, and the results are listed in table (4). When compared to the positive control group, treatment with tomato and eggplant peels at various dosages resulted in significant ($P \leq 0.05$) reductions in uric acid, creatinine, and urea levels. When compared to the positive control group, all mean values of groups 3, 4, 5, and 6 demonstrated a significant decrease in kidney function enzymes. These findings were comparable to those of Okongwu *et al.* (38) who discovered that eggplant is highly recommended for people who are at risk of kidney illness. Kazim *et al.* (39) indicated this for the tomato diet, reporting that tomato powder enhanced liver and kidney functioning.

Table (4): Effect of tomato peels and eggplant peels on kidney functions (urea, uric acid and creatinine) of obese rats at the end expermintal peroid

Parameter Groups	Urea (mg/dl) Mean ± SD	Uric acid (mg/dl) Mean ± SD	Creatinine (mg/dl) Mean ± SD
G1: Control –ve	30.05f ± 0.01	3.51f ± 0.06	0.45e ± 0.009
G2: Control +ve	52.14a ± 0.25	9.17a ± 0.01	0.83a ± 0.001
G3: Tomato peel (2%)	45.02b ± 0.05	4.8b ± 0.09	0.66b ± 0.008
G4: Tomato peel (5%)	40.17c ± 0.36	4.61c ± 0.07	0.65b ± 0.002
G5: Eggplant peel (2%)	39.23d ± 0.09	4.24d ± 0.03	0.63c ± 0.004
G6: Eggplant peel (5%)	35.07e ± 0.07	4.03e ± 0.05	0.61d ± 0.007
LSD	0.33	0.10	0.011

Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05).%Change of (+ve) control group.*

Table (6) shows the liver enzymes of obese rats treated with varied concentrations of tomato and eggplant peels (2&5%). In comparison to the normal control, a high fat diet generated a substantial rise (P≤0.05) in alkaline phosphatase (ALP), glutamic oxaloacetate transaminase (GOT), and glutamic pyruvic transaminase (GPT) (U/L) in alkaline phosphatase (ALP), glutamic oxaloacetate transaminase (GOT), and glut. The use of varied concentrations of tomato and eggplant peels reduced the rise in mean serum GOT, GPT, and ALP activity. Bernal *et al.* (40) found that lycopene in tomatoes prevents the development of steatosis and inhibits the development of alcoholic fatty liver. Nwanna *et al.* (34) found that a supplemented eggplant diet resulted in a significant reduction in lipid profile, decreased liver leakages, and decreased kidney function enzymes, as well as the restoration of depleted endogenous antioxidant enzymes.

Table (6): Effect of tomato peels and eggplant peels on liver functions (GOT, GPT, GOT/GPT and ALP) enzymes of obese rats at the end expermintal peroid

Parameter Groups	GOT (U/L) Mean ± SD	GPT (U/L) Mean ± SD	GOT/GPT Mean ± SD	ALP (U/L) Mean ± SD
G1: Control –ve	44.16f ± 0.29	36.15f ± 1.78	1.223c ± 0.052	144.12f ± 1.58
G2: Control +ve	88.23a ± 0.72	96.07a ± 1.85	0.918f± 0.009	266.31a± 0.26
G3: Tomato peel 2%	86.53d ± 0.65	80.34b ± 1.11	1.076d ± 0.005	184.09b ± 2.75
G4: Tomato peel 5%	78.32c ± 0.16	77.14c ± 1.66	1.012e ± 0.01	180.32c ± 1.16
G5: Eggplant peel 2%	75.13d ± 0.84	68.32b ± 1.52	1.096c ± 0.006	175.26d ± 1.62
G6: Eggplant peel 5%	70.38e ± 0.42	55.73e ± 1.01	1.257a± 0.006	169.37e ± 1.03
LSD	1.01	2.71	0.0123	2.83

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

The effect of feeding diabetic rats' tomato and eggplant peels (2&5%) on BWG (g/d/r), FI ((g/d/r), and FER is shown in table (6). The control (-) group's mean body weight gain (BWG) was lower than the control (+) group's, at 0.80 0.009 and 0.95 0.003 (g/d/r), respectively, revealing a significant difference with a percent drop of -15.79 percent. When compared to the control (+) group, all diabetic rats fed diverse diets showed significant differences. When compared to control (+), groups 5 (eggplant peels 2 percent) and 6 (eggplant peels 5 percent) had the best body weight growth. The mean value of feed intake (FI) (Table 6) of control (-) group was lower than control (+) group, being 23.74 ± 0.007& 38.0 ± 0.22 (g/d/r) respectively which revealed significant difference with percent of decrease -37.53 of control (-) group as compared to control (+) group. All diabetic rats fed on different diets showed significant differences as compared to control (+) group. Groups 5&6 (eggplant peels 2% & eggplant peels 5%) recorded the best groups for feed intake when compared to control (+).
The data in table (6) also showed the average FER of diabetic rats fed various diets. The data demonstrate that the control (-) group's mean FER was higher than the control (+) group's, at 0.034±0.0009 and 0.026± 0.0004g, respectively, revealing a significant difference with a percent drop of -30.77 percent in the control (-) group compared to the control (+) group. When compared to the control (+) group, all diabetic rats showed significant changes. When compared to the control (+), Group 6 (5% eggplant peels) had the highest feed efficiency ratio. These findings are in line with those of Mahsa *et al.* (42) who found that tomato juice decreases oxidative stress in overweight (and maybe obese) females, potentially preventing obesity-related illnesses and promoting health. In animal research, Ruyuan *et al.* (43) suggested that lycopene consumption helps to protect against diabetes and obesity.

Table (6): Effect of tomato peels and eggplant peels on body weight gain (BWG), food intake (FI) and feed Efficiency ratio (FER) of diabetic rats

Parameter / Groups	BWG (g/day/r) Mean ± SD	FI (g/day/r) Mean ± SD	FER Mean ± SD
G1: Control –ve	0.80b ± 0.009	23.74b ± 0.007	0.034a ± 0.0009
G2: Control +ve	0.95a ± 0.003	38.0a ± 0.22	0.026d ± 0.0004
G3: Tomato peel (2%)	0.53d ± 0.001	19.63c ± 0.009	0.027d ± 0.0005
G4: Tomato peel (5%)	0.52e ± 0.009	19.26d ± 0.002	0.027d ± 0.0009
G5: Eggplant peel (2%)	0.50d ± 0.004	16.67f ± 0.008	0.030c ± 0.0001
G6: Eggplant peel (5%)	0.55c ± 0.008	17.19e ± 0.004	0.032b ± 0.0003
LSD	0.01	0.16	0.001

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

Table (7) shows the effect of different doses of tomato and eggplant peel on serum blood glucose in alloxan-induced diabetic mice. The results showed that alloxan injection caused a substantial increase in serum glucose (p0.05) when compared to a control group. In diabetic groups, treatment with tomato and eggplant peels (2&5%) prevented mean glucose concentrations from increasing. These findings corroborated those of Okafor (44) and Aborehab *et al.* (35) who found that eggplant and tomato could both lower serum glucose levels. The same finding was made by Rela *et al.* (45), who discovered that eggplant (*Solanum melongena*, L.) extract might bring diabetic mellitus (DM) rats' blood glucose levels closer to normal. Tomato peel powder (ultrafine) Supplementation with TPUP could lower fasting blood glucose (FBG) levels in diabetic rats and total cholesterol (TC) levels in rats fed a high-fat diet (46). Supplementing with dry tomato peel (DTP) appears to help with insulin resistance (47).

Table (8) shows that rats given with tomato and eggplant peels (2&5%) had a substantial drop in blood triglyceride, total cholesterol, LDL-c, VLDL-c, and a significant increase in HDL-c compared to the positive control. The total cholesterol of rats treated with eggplant peels 5 percent fell to 138.51 mg/dl, compared to 180.38 mg/dl in the positive control group (mg/dl). In addition, as compared to the positive control, rats treated with eggplant peels had a considerable drop in triglycerides, reaching 72.34 (mg/dl) instead of 95.13 (mg\dl). The results, on the other hand, showed a considerable increase in HDL-c in rats fed with eggplant peels for 5% of the time, reaching 60.07 (mg/dl) when compared to the positive control, which reached 40.31 (mg/dl). The results showed that rats treated with eggplant peels 5 percent had a lower LDL-c level, reaching 63.97 mg/dl, compared to 121.04 mg/dl in the positive control group. It could be observed that diabetes raised TC, TG, VLDL, LDL & AI, while HDL reduced. The reverse was found when feeding on tomato & eggplant peels diets especially in case of eggplant peel diet. Mohamed *et al.*, (48) found that eggplant, particularly the peel, was more helpful for lowering hyperlipidemia and hypertension as well as improving lipid profile, but the long white variety was more effective for lowering hyperglycemia.

Table (7): Effect of tomato and eggplant peels on serum glucose of diabetic rats

Groups	Glucose (mg/dl): Mean ± SD
G1: Control –ve	131.31e ± 1.15
G2: Control +ve	328.12a ± 2.89
G3: Tomato peel (2%)	166.24b ± 2.04
G4: Tomato peel (5%)	157.09c ± 2.76
G5: Eggplant peel (2%)	155.14c ± 2.22
G6: Eggplant peel (5%)	149.31d ± 2.57
LSD	4.170

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

The mean value of serum urea in diabetic rats fed on different diets is shown in Table 9. The control (-) group's mean urea value was lower than the control (+) group's, at 30.05 0.01 and 50.13 0.26 (mg/dl), respectively, revealing a significant difference with a percent decrease of -40 percent in the control (-) group compared to the control (+) group. When compared to the control (+) group, all diabetic rats fed various diets showed substantial declines in mean values. When compared to the other treatments, the 5 percent eggplant peels (group 6) proved to be the most effective. Table 9 also included the mean value of serum uric acid (mg/dl) in diabetic rats fed various diets. The control (-) group's mean uric acid value was lower than the control (+) group's, at 3.510.06 and 8.660.08 (mg/dl), respectively, revealing a significant difference with a percent decrease of 59.30 percent in the control (-) group compared to the control (+) group.

Table (8): Effect of tomato and eggplant peels on serum lipid profile of diabetic rats

Parameter Groups	TC (mg\dl) Mean ± SD	TG (mg\dl) Mean ± SD	HDL (mg/dl) Mean ± SD	LDL (mg/dl) Mean ± SD	VLDL (mg/dl) Mean±SD
G1: Control –ve	125.73f ± 2.21	60.07f ± 1.25	61.64a ± 0.26	52.08f ± 1.19	12.01e ± 0.25
G2: Control +ve	180.38a ± 1.18	95.13a ± 0.13	40.31e ±1.18	121.04a ± 1.91	19.03a ± 0.24
G3: Tomato peel (2%)	166.15b ± 1.86	88.16b ± 0.24	48.92d ± 1.23	99.6b ± 1.15	17.63b ± 0.69
G4: Tomato peel (2%)	150.16c ± 1.05	86.26c ± 0.85	51.44c ± 1.62	81.47c ± 1.24	17.25b ± 0.21
G5: Eggplant peel (2%)	146.32d ± 1.77	75.41d ± 0.77	58.34b ± 1.41	72.9d ± 1.74	15.08c ± 0.05
G6: Eggplant peel (5%)	138.51e ± 1.24	72.34e ± 0.53	60.07ab ± 1.89	63.97e ± 1.53	14.47d ± 0.07
LSD	2.841	1.306	2.426	2.648	0.585

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

When compared to the control (+) group, all diabetic rats fed various diets showed substantial declines in mean values. In terms of uric acid, group 6 (eggplant peels (5%) was the best treatment. Data in table (9) also illustrated the mean value of serum creatinine of diabetic rats fed on various diets. It could be noticed that the mean value of creatinine of control (-) group was lower than control (+) group, which were 0.45 ± 0.009& 0.76 ± 0.009 (mg/dl) respectively which revealed significant difference with percent of decrease -40.79% of control (-) group as compared to control (+) group. When compared to the control (+) group, all diabetic rats fed various diets showed substantial declines in mean values. In terms of creatinine, group 6 (eggplant peels (5%)) was the best treatment.

Table 10 shows the liver function of alloxan-induced diabetic rats treated with various concentrations of tomato and eggplant peels (10). Injection of alloxan resulted in a substantial increase (p 0.05) in alkaline phosphatase (ALP), Glutamic oxaloacetate transaminase (GOT), and Glutamic pyruvic transaminase (GPT) when compared to the normal control. The use of varying concentrations of tomato and eggplant peel reduced the rise in mean serum GOT, GPT, and ALP activity. These findings were corroborated by Nwozo *et al.* (49) who discovered that eggplant improved liver function and regulated lipid profile levels. Tomato lycopene, according to Vanessa *et al.* (50), prevents cardiovascular disease and nonalcoholic hepatic steatosis. The elevated plasma and hepatic levels in obese rats caused by a high-fat diet could be reduced by eating tomato paste (51). Antioxidants, such as flavonoids present in *Solanum melongena* fruit, can prevent hepatocyte necrosis. In a rat model of histopathology, Solanum melongena fruit infusion exhibits hepatoprotective benefits against acute hepatitis (41).

Table (9): Effect of tomato peels and eggplant peels on kidney functions (urea, uric acid and creatinine) of diabetic rats at the end expermintal peroid

parameter Groups	Urea (mg/dl) Mean ± SD	U.A (mg/dl) Mean ± SD	Creatinine (mg/dl) Mean ± SD
G1: Control –ve	30.05f ± 0.01	3.51f ± 0.06	0.45f ± 0.009
G2: Control +ve	50.13a ± 0.26	8.66a ± 0.08	0.76a ± 0.009
G3: Tomato peel (2%)	40.09b ± 0.15	4.37b ± 0.01	0.58c ± 0.002
G4: Tomato peel (5%)	38.23c ± 0.58	4.11c ± 0.03	0.66b ± 0.007
G5: Eggplant peel (2%)	34.17d ± 0.34	3.85d ± 0.09	0.52d ± 0.001
G6: Eggplant peel (5%)	32.64e ± 0.41	3.62e ± 0.02	0.48e ± 0.003
LSD	0.612	0.101	0.011

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

Table (10): Effect of tomato peels and eggplant peels on liver functions (GOT, GPT, GOT/GPT and ALP) enzymes of diabetic rats

parameter Groups	GOT (U/L) Mean ± SD	GPT (U/L) Mean ± SD	GOT/GPT Mean ± SD	ALP (U/L) Mean ± SD
G1: Control –ve	44.16f ± 0.29	36.15e ± 1.78	1.223c ± 0.052	144.12b ± 1.58
G2: Control +ve	83.02a ± 1.24	92.46a ± 0.25	0.898d ± 0.011	260.34a ± 1.11
G3: Tomato peel (2%)	70.11b ± 1.78	48.55b ± 0.01	1.444a ± 0.036	145.47b ± 0.82
G4: Tomato peel (5%)	64.29c ± 1.19	47.12c ± 0.09	1.364b ± 0.023	141.39c ± 0.42
G5: Eggplant peel(2%)	59.17d ± 1.65	44.17d ± 0.09	1.339b ± 0.035	138.06d ± 0.16
G6: Eggplant peel (5%)	48.62e ± 1.06	37.24e± 0.07	1.306b ± 0.026	141.12c ± 0.57
LSD	2.303	1.309	0.059	1.612

*Means with the different superscript letters in the same column were significant different at (P<0.05). LSD: Least significant differences (P<0.05). *%Change of (+ve) control group.*

In conclusion

Tomato and eggplant peels are an essential source of numerous healthful components, including diabetes and obesity-fighting compounds, according to this study. Anthocyanin, found in eggplant, protects against diabetes, neurological diseases, cardiovascular disease, and cancer. Lycopene functions as an anti-diabetic drug by reducing free radicals and improving serum levels that have returned to normal. As a result of these discoveries, we should include tomato and eggplant peels in our everyday diets, drinks, and food supplements.

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دراسات كيموحيوية بيولوجية علي قشور الطماطم والباذنجان عند إضافتها لتخفيف السمنه والسكري في الفئران البيضاء

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الملخص العربي :

أجريت الدراسة لمعرفة التأثير الصحي المحتمل لبعض قشور النباتات علي الفئران المصابة بالسمنة التي تغذت علي نظام غذائي عالي الدهون والسكر للفئران التي تم حقنها بالألوكسان . تم إستخدام 55 فأرا بالغ وتقسيمهم ثلاث مجموعات ، المجموعة الأولى (5 فئران) مجموعة ضابطة سالبة. المجموعة الثانية (25 فأرا) تغذت على نظام غذائي عالي الدهون للإصابة بالسمنة ، ثم قسمت إلى خمس مجموعات (5 فئران لكل مجموعة) ، واحدة منهم مجموعة ضابطه موجبة وتغذت علي الوجبة الأساسية ، بينما تغذت المجموعات الأربع المتبقية على الوجبة الأساسية المحتوية علي مسحوق قشر طماطم 2 ٪ ,قشر الطماطم 5٪ ,قشر الباذنجان 2٪ وقشر الباذنجان 5٪ علي التوالي. المجموعة الثالثة (25 فأرا) حقنت بالالوكسان للإصابة بمرض السكر, ثم قسمت الى خمس مجموعات أخري (5 فئران لكل مجموعة), واحده منهم مجموعة ضابطه موجبة وتغذت علي الوجبة الأساسية، بينما تغذت المجموعات الأربع المتبقية على الوجبة الأساسية المحتوية علي مسحوق قشر طماطم 2 ٪ ,قشر الطماطم 5٪ ,قشر الباذنجان 2٪ وقشر الباذنجان 5٪ علي التوالي. استمرت التجربة لمدة 28 يومًا. وسجلت النتائج أن قشر الباذنجان 5٪حيث كانت 2.44 ± 147.08 ,1.24 ± 138.51 علي التوالي أقصى انخفاض في الكوليسترول الكلي و مؤشر تصلب الشرايين في السمنة ومرض السكر، سجلت قشور الباذنجان 5٪ في الغالب أفضل النتائج في تحسين نسبة إنزيمات الكبد في السمنة ومرض السكري. سجل قشر الباذنجان 5٪ أفضل النتائج في تحسين وظائف الكلى في السمنة ومرض السكر. وتوصلت النتائج إلى أن قشر الطماطم 2٪ ، قشر الطماطم 5٪ ، قشر الباذنجان 2٪ ، قشر الباذنجان 5٪ يمكن استخدامهم لتقليل اعراض مرض السمنة والسكر.

الكلمات المفتاحية: السمنة، السكر، البروتينات الدهنية، قشور الطماطم والباذنجان، الفئران