

**EFFECT OF GOLDEN BERRY (*Physalis peruviana*)
FRUITS AND ITS PEELS ON ACUTE
HEPATOTOXICITY WITH DIABETIC RATS**

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ABSTRACT

The use of traditional medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has been widely observed. Therefore, the aim of the present study was to investigate the effect of Golden Berry (*Physalis peruviana*) fruits and its peels on acute hepatotoxicity with diabetes. Thirty six adult male rats were classified into 6 groups (6 rats each), Group (1), were fed on basal diet (control negative group). Rats (n=30) were injected by single intraperitoneal freshly prepared Streptozotocin (60 mg/kg b.wt.), these Animals were randomly enrolled into five groups as following: Group (2), diabetic rats were fed on basal diet (control positive group). Groups (3 and 4), diabetic rats were fed on basal diet supplemented with 5% and 10% dried golden berry fruit respectively. Group (5 and 6), diabetic rats were fed on basal diet supplemented with 5% and 10% dried peel of golden berry, respectively. All rats except control negative will be subcutaneous injected by carbon tetrachloride (Ccl₄), twice at the end of experimental (4 weeks) feeding period to induce acute hepatotoxicity .

The results of the current study showed that basal diet supplemented with dried golden berry fruit or golden berry peels at the two studied level (5% and 10 %) caused a significant decrease (P<0.05) in the elevated level of serum glucose, urea, uric acid, creatinine, triglycerides, total cholesterol, low density lipoprotein, very low density lipoprotein, aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase levels, and significantly increased (P<0.05) the concentrations of high density lipoprotein and insulin activity as compared to the control diabetic rats. No statistical changes among the treated groups for all parameters were observed. It could be concluded that, golden berry fruit and peels improve the abnormal glucose metabolism, hyperlipidemia and increase insulin secretion as well alleviate hepatotoxicity associated with diabetes. Therefore, Golden berry and its peel might be used to treat diabetic patients and prevent diabetes complications such as hepatotoxicity.

INTRODUCTION

The worldwide prevalence of diabetes mellitus has risen dramatically over the past two decades, from an estimated 30 million cases in 1985 to 285 million in 2010. Based on current trends, the International Diabetes Federation reported that 438 million individuals will have diabetes by the year 2030 (Longo et al., 2012). Microvascular (retinopathy and nephropathy) and macrovascular (atherosclerotic) disorders will develop if long-term diabetes is not effectively controlled (Liu et al., 2015).

The use of traditional medicine and medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has been widely observed (Tiwari and Madhusudanarao, 2002). Plants have always been rich sources of medicinally active constituents in the quest for curing numerous diseases. *Physalis peruviana* var. *latifolia* (*P. peruviana*) known as cape gooseberry or golden berry, belongs to Solanaceae family and is grown in Egypt, Colombia, South Africa, India, New Zealand, Australia, Zimbabwe, Kenya and Great Britain. Colombia is one of its largest producer, consumer and exporter. The genus *Physalis* includes around 100 species characterized via fruits bearing an inflated calyx (Whitson and Manos, 2005).

Physalis peruviana has been utilized traditionally as a therapeutic (anticancer antipyretic, immune modulatory, antispasmodic, diuretic, antiseptic, sedative analgesic, helping to fortify the optic nerve, throat relief, elimination of intestinal parasites, amoebas as well as albumin from kidneys and also for treating diseases such as malaria, asthma, dermatitis, rheumatism and hepatitis (Hassaien, 2011).

It contains numerous active components like essential minerals, α -linolenic acid, iron, vitamins, carbohydrates, phytosterols etc. Its potential as a multifunctional agent in beverages, foods and nutraceutical industries makes it an important crop for consideration (Singh et al., 2019). Commercial importance of *P. peruviana* has increased due to its health-promoting traits such as high levels of carotenoids, vitamin C, minerals, and antioxidant potential (Etzbach et L., 2019).

This study was conducted to evaluate the effect of golden berry (*physalis peruviana*) fruits and its peels at two levels (5 and 10%) on acute hepatotoxicity with diabetic rats

MATERIALS AND METHODS

Materials:-

Plant: Golden Berry (*Physalis peruviana*) fruits was obtained from agricultural research center. **Chemicals:** Streptozotocin (STZ) and CCl_4 were obtained from local distributor of (Sigma Chemical Co) Cairo, Egypt. Casein, vitamins, minerals, cellulose and L-cysteine were

purchased from El-Gomhorya Company for Chemical and Pharmaceutical, Cairo, Egypt. Kits for blood analysis were purchased from Alkan Company for Biodiagnostic Reagents, Dokki, Giza, Egypt. **Rats:** adult male albino rats (Sprague- Dawley strain) (n=36 rats) weighting approximately (200±5g) were purchased from Helwan Experimental Animals Farm.

A. Preparation of materials: Golden Berry with peels was washed, brushed under distilled water, air dried and hand peeled. Banana Fruits and isolated peels from the flesh were dried using solar energy at (National Research Center, Dokki, Giza), then were grinded by an electric Grinder.

B. Experimental animals:

Thirty six adult male rats were fed on basal diet prepared according to (Reeves et al., 1993) for one week before the experiment for adaptation. The animals housed individually in stainless steel cages under controlled condition, at the Animal House of Faculty of Home Economic, Helwan University. Diabetes was induced to rats by single intraperitoneal injection of freshly prepared Streptozotocin (60 mg/kg b.wt.). Three days after STZ administration, serum glucose level of each rat was measured. Rats with fast serum glucose (≥ 200 mg/dl) were considered diabetic (Sarkar et al., 1996).

Animals were randomly enrolled into six groups (6 rats each) as following: Group (1), rats were fed on basal diet (control negative group). Group (2), diabetic rats were fed on basal diet (control positive group). Groups (3 and 4), diabetic rats were fed on basal diet supplemented with 5% and 10% dried Golden Berry fruit respectively. Group (5 and 6), diabetic rats were fed on basal diet supplemented with 5% and 10% dried peel of Golden Berry fruit, respectively.

All rats except control negative will be subcutaneous injected by carbon tetrachloride Ccl_4 that diluted by paraffin oil (1:1) { in a dose of 2 ml /kg of BW. of rat}, twice at the end of experimental feeding period to induce acute hepatotoxicity according to the method described by (Wilfried, et al., 1994)

Each rat was weighted at the end of experiment and feed intake (FI) was also recorded daily. At the end of experimental period (4 weeks), rats were sacrificed after overnight fasting and blood of each rat was taken from the abdominal aorta under anesthesia by diethyl ether. The serum was separated by leaving the blood samples 15 minutes at room

temperature then centrifuged at 3000 rpm for 20 minutes, and then kept in plastic vials at -20°C until biochemical analysis.

The biological effect of different levels of banana fruits and its peel were assessed by the determination of body weight gain percent (BWG%) and feed efficiency ratio (FER) according to the method of **Chapman *et al.*, (1959)**.

C. Biochemical analysis of serum:

Insulin activity was estimated using enzyme linked immunosorbent assay ELISA method as described by **Clark and Hales, (1994)**. Glucose level was determined according to **Asatoor and King, (1954)**. Calorimetric determination of total cholesterol (TC) and triglycerides (TG) were carried out according to the method of **Richmond, (1973)** and **Fossati and Praneipe, (1982)** respectively. Determination of high density lipoprotein (HDL-c) level was carried out according to the method of **Richmond, (1973)**. Very low density lipoprotein (VLDL-c) and low density lipoprotein (LDL-c) were calculated according to the equation of **Friedewald *et al.*, (1972)**. Serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined according to method of **Reitman and Frankel, (1957)**. Serum alkaline phosphatase (ALP) is estimated by method of **Belfield and Goldberg, (1971)**. Serum creatinine, urea and uric acid level was determined by the method **Tietz, (1999)**, **Wills and Savory, (1981)** and **Patton and Crouch, (1977)** respectively.

D. Statistical analysis:

The results were expressed as mean \pm SE. The statistical analysis was carried out by using SPSS, PC statistical software (Version 19.0 SPSS Inc., Chicago, USA) using the Duncan' test multiple range post-hoc test. Data was analyzed by one way analysis of variance (ANOVA). The values were considered significantly different at ($P < 0.05$) (**Zar, 1984**)

RESULTS AND DISCUSSION:

As seen in table (1), there was no significant changes in IBW of all rats as compared to control groups. The FBW of the positive control group was significantly lowered as compared to negative control group. supplementation with Golden berry and its peels at the two tested levels caused a significant increase in the FBW as compared to +ve group. No significant changes of FBW among the treated groups. Regarding to BWG% and FER, it was cleared that the +ve group had significant decreased in BWG% and FER as compared to -ve group, while the

supplementation with the tested materials at 5 and 10% significantly increased the BWG% and FER as compared to +ve group. Moreover, there was no statistical changes in BWG% and FER among all treated groups *P. peruviana* is grown in Columbia, India, Egypt, South Africa, and Australia (Ramadan, 2011). Commercial importance of *P. peruviana* has increased due to its health-promoting traits such as high levels of carotenoids, vitamin C, minerals, and antioxidant potential (Etzbach et al., 2019).

Table (1): Effect of Golden Berry fruits and its peels on body weight status of acute hepatotoxic diabetic rats.

Parameters	IBW (g)	FBW (g)	BWG%	FI/day	FER
Control (-ve)	200.00±1.32 ^a	250.00±2.02 ^a	25.00±0.86 ^a	16.00	0.104±0.05 ^a
Control (+ve)	203.50±1.05 ^a	181.20±2.43 ^c	-10.95±1.84 ^c	19	-0.039±0.08 ^c
Golden Berry fruit (5%)	202.75±1.41 ^a	218.50±2.74 ^b	7.76±1.22 ^b	13.50	0.038±0.16 ^b
Golden Berry fruit (10%)	203.00±1.80 ^a	225.75±2.35 ^b	11.20±1.00 ^b	14	0.054±0.12 ^b
Golden Berry peels (5%)	201.30±1.11 ^a	219.50±2.74 ^b	9.04±1.34 ^b	12.00	0.050±0.06 ^b
Golden Berry peels (10%)	202.50±1.08 ^a	223.30±2.01 ^b	10.27±1.50 ^b	14.50	0.047±0.10 ^b

Values are expressed as Means ± SE.

Values at the same column with different letters are significant different at $P < 0.05$.

The level of glucose of the positive control group was significantly increased as compared to the corresponding value of the -ve group as illustrated in table (2). Rats treated with golden berry fruit or peels at 5 and 10% had lowered the elevated level of glucose as compared to -ve group. the percent of glucose reduction ranged from 49.79 to 58.39%. There was a significant change in serum glucose between the groups fed golden berry fruit at 5 and 10 % as well as at the groups fed golden berry peels. The highest improvement of glucose level was recorded at the rats fed on golden berry peels at 10%.

Regarding to serum insulin activity, STZ injection caused a significant decrease of insulin level as compared to +ve group. The concentration on insulin was significantly increased for all treated groups as compared to the +ve group. There was no significant change in serum insulin level between the groups fed golden berry fruit at 5 and 10 % as well as at the groups fed golden berry peels.

Golden berry can be effective food-based strategies for anti-diabetic and anti-hypertensive effect (Pinto et al., 2009). *P. peruviana* fruit contains 15% soluble solids, mainly sugars and its high level of fructose makes it valuable for people with diabetes (Hassaien, 2011). The anti-diabetic potential of *P. peruviana* fruit in high-fat diet rats was explored. Physalis polyphenols may, therefore, prevent the damage and death of pancreatic β -cells and/or stimulate the regeneration of this type

of cells in diabetic rats. It has been reported that the administration of polyphenols, such as quercetin and epicatechin, to surviving diabetic rats protect the architecture of pancreatic β -cells, preserves the secretion of insulin and stimulates the regeneration of this type of cells (Hassan and Ghoneim, 2013)

It was reported that the fruit extract improved insulin sensitivity and possess significant anti-diabetic effect which probably was due to the active ingredients present within the extract (Sathyadevi et al., 2014). Also, in Chinese folk medicine, *P. peruviana* fruits were consumed and have also been reported for diabetes mellitus treatment. A study suggested that one of the modes of action for the anti-hyperglycemic property of this fruit is its inhibition of intestinal carbohydrase enzyme (Rey et al., 2015). Dry powder formulation of *P. peruviana* fruit extract can prove to be a future phytotherapeutic agent and can be utilized for the treatment of diabetes (Bernal et al. 2016).

Abd El-Gwad et al., (2018) found that goldenberry (ethanolic goldenberry extract 500 mg/kg b.wt) could be has therapeutic effect for diabetes and considered as a new source of bioactive and functional food.

Table (2): Effect of Golden Berry fruits and its peels on glucose and insulin level of acute hepatotoxic diabetic rats.

Parameters	Glucose (mg/dl)	%of glucose reduction	Insulin (mIU/ml)
Control (-ve)	93.00±1.41 ^c	-	17.11±0.34 ^a
Control (+ve)	275.03±2.25 ^a	-	6.89±0.57 ^d
Golden Berry fruit (5%)	138.08±2.25 ^b	49.79	12.10±0.45 ^c
Golden Berry fruit (10%)	130.88±1.67 ^c	52.41	14.00±0.65 ^{bc}
Golden Berry peels (5%)	121.25±1.46 ^d	55.91	14.34±0.35 ^b
Golden Berry peels (10%)	114.43±1.08 ^e	58.39	15.76±0.45 ^b

Values are expressed as Means \pm SE.

Values at the same column with different letters are significant different at $P < 0.05$.

Table (3) indicated the effect of Golden Berry (*Physalis Peruviana*) fruits and its peels on kidney functions of acute hepatotoxic diabetic rats. STZ injection caused a significant increase in kidney function (urea, uric acid and creatinine) compared to - ve group. Supplementation with Golden Berry fruit or peels at 5 and 10% caused a significant decreased in serum uric acid, creatinine and urea as compared to +ve group. There was a significant decrease in serum uric acid for the rats fed Golden Berry fruit at 10% as compared to 5%, while there was no change in the level of serum uric acid between rats fed Golden Berry

peels at 5 and 10%. The level of creatinine was significantly lowered at the groups fed Golden Berry fruit 10% as compared to Golden Berry fruit 5%.

The same difference was observed between the rats fed the Golden Berry peels. Regarding to serum urea, there was no significant change between the rats fed either Golden Berry fruit 5 and 10%, but supplementation with Golden Berry peels at 10% caused a significant decrease of serum urea as compared to rats fed Golden Berry fruit at 5%. The highest improvement of serum kidney functions was recorded at Golden Berry peels at 10%.

Nephroprotective activity of *Physalis peruviana* is also the result of free radical scavenging. Increase in the antioxidant defence system and a larger susceptibility of the kidney to oxidant stress might be anticipated. Researchers by their *in-vivo* experiments confirmed its beneficial effects (Moneim and El-Deib, 2012).

Supplementation with *Physalis peruviana* L. extract (100 and 150 mg PPE/kg body weight) caused a significant increment in body weight, feed intake (Ahmed, 2014).

Table (3): Effect of Golden Berry fruits and its peels on kidney functions of acute hepatotoxic diabetic rats.

Parameters	Uric acid	Creatinine	Urea
	(mg/dl)		
Control (-ve)	1.00±0.07 ^d	0.61 ±0.02 ^d	40.13±1.88 ^e
Control (+ve)	2.97±0.20 ^a	2.00±0.01 ^a	80.00±2.98 ^a
Golden Berry fruit (5%)	1.86±0.03 ^b	1.47±0.05 ^b	60.70±0.66 ^b
Golden Berry fruit (10%)	1.60±0.08 ^c	0.98±0.02 ^c	57.10±1.02 ^{bc}
Golden Berry peels (5%)	1.52±0.10 ^c	1.40±0.11 ^b	54.24±1.11 ^c
Golden Berry peels (10%)	1.44±0.03 ^c	0.93±0.01 ^c	48.86±1.23 ^d

Values are expressed as Means ± SE

Values at the same column with different letters are significant different at P<0.05.

The effect of Golden Berry (*Physalis Peruviana*) fruits and its peels on lipid profile of acute hepatotoxic diabetic rats was illustrated at table (4). The supplementation with either Golden Berry fruit at 5 and 10% or Golden Berry peels at the same levels significantly lowered the mean level of serum TC, TG, VLDL-c and LDL-c, while HDL-c was significantly increased as compared to control positive group. It was observed that, there were no significant changes between the groups fed Golden Berry fruit at 5 and 10% as well as between the groups fed on Golden Berry peels at 5 and 10% for serum TC, TG, VLDL-c. Serum

HDL-c was significantly increased for the groups fed on Golden Berry peels at 10% as compared to the group fed on Golden Berry peels at 5%.

Moreover, it was cleared that rats fed on Golden Berry peels at 10% had significant decrease in the level of serum LDL-c as compared to the group fed on Golden Berry peels 5%. The highest improvement of lipid profile was recorded at the groups that fed on Golden Berry peels at 10% followed by the level of 5%.

Table (4): Effect of Golden Berry (*Physalis Peruviana*) fruits and its peels on lipid profile of acute hepatotoxic diabetic rats.

Parameters Groups	TC	TG	HDL-C	VLDL-C	LDL-C
	(mg/dl)				
Control -ve	116.87±1.14 ^e	97.24±1.45 ^e	64.58±2.08 ^a	19.44±0.44 ^d	32.82±1.99 ^e
Control +ve	170.40±1.35 ^a	220.20±2.71 ^a	32.17±1.07 ^d	44.04±0.36 ^a	94.19±2.11 ^a
Golden Berry fruit (5%)	134.50±1.40 ^b	140.34±1.03 ^b	47.50±1.45 ^c	28.06±0.48 ^b	58.93±1.37 ^b
Golden Berry fruit (10%)	131.33±1.35 ^{bc}	135.50±1.40 ^{bc}	48.33±1.63 ^c	27.10±0.28 ^{bc}	55.90±1.48 ^{bc}
Golden Berry peels (5%)	126.34±1.08 ^{cd}	131.16±1.33 ^{cd}	50.67±1.06 ^c	26.23±0.54 ^{cd}	49.43±1.73 ^c
Golden Berry peels (10%)	122.00±1.12 ^d	125.66±1.38 ^d	57.00±1.00 ^b	25.13±0.27 ^d	39.86±0.9 ^d

Values are expressed as Means ± SE .

Values at the same column with different letters are significant different at P<0.05.

Physalis peruviana has excellent potential as a food-based strategy as antidiabetes and antihypertension solutions (Pinto et al., 2009). In addition, the consumption of *Physalis peruviana* pomace provides an overall beneficial effect in suppressing high cholesterol diet-induced hypercholesteremia (Ramadan et al., 2012).

Kirecci et al., (2018) results validate the use of goldenberry and lupin fruits as a treatment against diabetes mellitus and its complications and suggest it is suitable to continue studies for its safe therapeutic use. Observations from animal and human studies have demonstrated antiinflammatory effects of phytosterols in addition to their well known effect on lowering cholesterol levels.

Table (5) showed the effect of Golden Berry (*Physalis Peruviana*) fruits and its peels on liver functions of acute hepatotoxic diabetic rats. The diabetic rats that suffered from hepatotoxicity had significant increase in the concentration of serum liver functions (ALT, AST and ALP) as compared to the -ve group.

Table (5): Effect of Golden Berry (*Physalis Peruviana*) fruits and its peels on liver functions of acute hepatotoxic diabetic rats.

Groups	Parameters	ALT	AST	ALP
		(μ/L)		
Control (-ve)		34.16±0.83 ^c	90.87 ±1.22 ^d	35.90±1.56 ^d
Control (+ve)		74.23±2.55 ^a	162.69 ±1.35 ^a	60.76±2.46 ^a
Golden Berry fruit (5%)		41.83±2.27 ^b	124.33 ±1.50 ^b	47.36±1.06 ^b
Golden Berry fruit (10%)		40.58±1.81 ^b	122.00 ±1.58 ^b	44.46±1.36 ^{bc}
Golden Berry peels (5%)		39.67±1.20 ^b	117.34±1.81 ^{bc}	43.93±1.55 ^{bc}
Golden Berry peels (10%)		35.00± 0.76 ^c	115.16 ±1.28 ^c	42.00±1.00 ^c

Values are expressed as Means ± SE

Values at the same column with different letters are significant different at P<0.05.

Carbon tetrachloride (CCl₄) is environmental pollutant which causes hepatotoxic effects by producing centrilobular necrosis and steatosis. It is reported that 6 hours after the treatment of CCl₄ (single dose, 2ml/kg) caused liver toxicity indicated by disturbance in biochemical marker enzymes in the serum (Vanitha, *et al.*, 2007).

The supplementation with either Golden Berry fruit at 5 and 10% or Golden Berry peels at the same levels significantly lowered the level of ALT, AST and ALP as compared to the +ve group. Feeding rats with Golden Berry fruit at 5 % didn't cause any changes on serum ALT, AST and ALP as compared to the group fed on Golden Berry fruit at 10%. On the other hand, supplementation with Golden Berry peels at 10% significantly lowered the level of AST, compared to Golden Berry peel at 5%, while no significant changes for AST and ALP between the groups fed on Golden Berry peels at 5 and 10%. The highest improvement of liver functions was observed at the groups fed on Golden Berry peels at 5 and 10%.

The ascorbic acid level in *P. peruviana* juice (46 mg/100 g) was higher than the ascorbic acid level in most fruit juices such as pear, apple, and peach (Belitz and Grosch, 1999). Quercetin followed by myricetin and kaempferol were the main phenolic compounds (Häkkinen *et al.*, 1999). These phytochemicals have reported to exhibit antioxidant traits and prevent oxidative damage in liver microsomes and hepatocytes (Wang *et al.*, 1999). High levels of total phenolics were measured in *P. peruviana* juice, whereas the total phenolic content was 6.3 mg as caffeic acid equivalent/100 g juice (Ramadan, 2019).

In-vivo studies indicated that *P. peruviana* fruit extract can stabilize the hepatic cell membrane and act as a hepatoprotective substance against the toxic effect of certain toxicants such as cadmium⁸³

and carbon tetrachloride (Arun and asha, 2007). Polyphenols are able to maintain the integrity of cell membranes, lowering effect ($p < 0.05$) in the elevated levels of serum markers like ALAT, ASAT, ALP, LDH, creatinine, urea and bilirubin indicating the protection against hepatic cell damage. This role is not related to enhancing the antioxidant activity. However, the possible mechanism of the protective function of *P. peruviana* fruit, aqueous or ethanolic extract may be due to their ability to scavenge free radicals and enhanced antioxidant effect or inhibition of cytochrome P (Taj et al., 2014).

Physalis peruviana has also been reported to have hepatoprotective activity (Chang, et al., 2008). The underlying mechanism behind the hepatoprotective mechanism may also be attributed to a decrease in the expression of a fibrotic marker matrix metalloproteinases (MMP-9). *P. peruviana* fruit juice lowered the MMP-9 expression and thus inhibited fibrosis, the effect found was probably owed to the presence of quercetin (a strong antioxidant) (Al-Olayan, 2014).

In conclusion: Supplementation with golden berry fruit and its peel at the levels of 5 and 10% significantly lowered the elevated blood glucose and increased the insulin concentration as well as improving lipid profile and liver and kidney functions of diabetic rats. These results could be due to components of golden berry fruit and its peel such as phenolic compounds, vitamins, minerals and fibers that possess antioxidant, hepatoprotective, antilipidemic and antidiabetic activities. Therefore, golden berry fruit and its peel might be used to treat diabetic patients and prevent diabetes complications such as hepatotoxicity.

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تأثير ثمار الحرنكش وقشورها علي التسمم الكبدي الحاد والسكر في الفئران

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تم ملاحظة استخدام النباتات الطبية التقليدية في معظم البلدان النامية نطاق واسع ، كأساس للحفاظ على الصحة الجيدة ، ولهذا كان الهدف من هذه الدراسة هو التحقق من تأثير ثمار الحرنكش وقشورها على التسمم الكبدي الحاد في الفئران المصابة بمرض السكري. تم تقسيم ستة وثلاثين من ذكور الفئران البالغة إلى 6 مجموعات (6 فئران لكل مجموعة) ، المجموعة (1) ، تم تغذيتها على النظام الغذائي الأساسي (المجموعة الضابطة السالبة). تم حقن باقي الفئران (ن = 30) بواسطة مادة استريزوتوسين في الغشاء البريتوني (60 ملجم / كجم وزن الجسم) ، تم تقسيم هذه الفئران بشكل عشوائي الى خمس مجموعات على النحو التالي: المجموعة (2) ، تم تغذية الفئران المصابة بداء السكري على النظام الغذائي الأساسي (المجموعة الضابطة الموجبة). المجموعتان (3 ، 4) ، الفئران المصابة بداء السكري تم تغذيتها على نظام غذائي أساسي مدعم بـ 5% ، 10% ثمار الحرنكش المجففة على التوالي. المجموعة (5 ، 6): تم تغذية الفئران المصابة بداء السكري على الغذاء الاساسى المضاف إليه 5% ، 10% قشر الحرنكش المجفف على التوالي. تم حقن جميع الفئران ماعدا المجموعة الضابطة السالبة تحت الجلد بواسطة رابع كلوريد الكربون (CCl4) مرتين في نهاية فترة التجربة (4 أسابيع) لاحداث التسمم الكبدي الحاد . أظهرت نتائج الدراسة الحالية أن النظام الغذائي الأساسي المدعم بفاكهة الحرنكش المجففة أو قشورها عند المستويين (5% ، 10%) أدى الى حدوث انخفاض معنوي ($P < 0.05$) في مستوى السكر المرتفع، اليوريا ، حمض البوليك ، الكرياتينين ، الدهون الثلاثية ، الكوليسترول الكلي ، الليبوبروتين المنخفض الكثافة ، الليبوبروتين منخفض الكثافة جدا، وانزيمات الكبد (ALT, AST, ALP) ، وحدثت زيادة ملحوظة ($P < 0.05$) في تركيزات الليبوبروتين عالي الكثافة ونشاط الأنسولين مقارنةً بالمجموعة الضابطة الموجبة. لم يلاحظ أي تغييرات إحصائية في المقاييس المختلفة بين المجموعات المعالجة. يمكن الاستنتاج أن ثمار الحرنكش وقشورها تعمل على تحسين الخلل في التمثيل الغذائي للجلوكوز وارتفاع دهون الدم كما تؤدي الى زيادة إفراز الأنسولين وكذلك تخفيف التسمم الكبدي المرتبط بمرض السكري. لذلك ، يمكن استخدام ثمار الحرنكش وقشورها لعلاج مرضى السكر ومنع مضاعفاته.