Original research Articles

Chemical and Biological studies on The goldenberry (*Physalis peruviana* L.) on hyperglycemic rats

Abstract

The aim this investigate was to see if the medicine goldenberry fruits (*Physalis peruviana* L.) could help lower blood sugar, cholesterol, and triglycerides. The results of the chemical composition of goldenberry fruits were found to be a high source of antioxidants and which contain a high level of hypoglycemic and hypocholesterolemic such as phenolic compounds, ascorbic acid and □-carotenoid. The results showed that dried goldenberry fruits powder could be added to replace up to 5 and 10 % of hyperglycemic -diet respectively. Experimental hyperglycemic rats were fed for six weeks on diet contain dried goldenberry at extent 5% or 10% except normal control (G1) was fed on basal diet. Hyperglycemic rats fed on diets substituted in a part with 5% and10 % dried goldenberry the results showed that supplementing the hyperglycemic-producing diets with the additive goldenberry had significant decrease in serum glucose, lipid profile (cholesterols, triglyceride, low density lipoprotein LDL and very low density lipoprotein vLDL-cholesterol). Meanwhile, high density lipoprotein HDL cholesterol increased with all treatments, significant reduction in alanine aminotransferase ALT, aspartate aminotransferase AST, alkaline phosphatase ALP, and total bilirubin values, in respect to positive control were also observed.

Key words: goldenberry, antioxidants, rats, hyperglycemic.

1.INTRODUCTION

The goldenberry (*P. peruviana* L.) is a Solanaceae fruit that is native to South America and is now commercially grown in a number of tropical and subtropical countries **[1].** Goldenberries are a type of annual plant that can be found all over the world. The fruit (*P. peruviana* L). is also known as goldenberry in English-speaking countries, uvilla in Ecuador, cape gooseberry in South Africa, uchuva in Colombia, ras bhari in India, topotopo in Venezuela and aguaymanto in Peru **[2].**

A single plant can produce 300 fruits, and well-managed plants can produce 20 to 33 tonnes per hectare. Goldenberry fruit has a yellow to orange skin colour, is ovoid in shape, and measures between 1.25 and 2.50 cm in diameter and weighs 4 to 10 g. The calyx protects the fruit, which contains around 100 to 200 small yellowish seeds **[3].** Goldenberries are well-known for their taste, odour, and colour, as well as their nutritional value (vitamins C and A, phosphorous, calcium and potassium) and health benefits. Goldenberries are commonly sold as fresh fruits, but they can also be used in sauces, syrups, and marmalades or dehydrated (in the same way as grape raisins are dehydrated) for use in bakeries, drinks, snacks, and cereal breakfasts **[4].**

It's a tropical plant with hairy, soft, heart-shaped, slender-pointed leaves and edible orange fruits. They are protected from birds and bugs by a thin protective covering that resembles a Chinese lantern **[5].**

The juice contains 72.6 percent of the total weight of the berry. The juice's pH was determined to be acidic (3.79-3.86). Provitamin A, vitamin B complex, ascorbic acid, and minerals are abundant in the fruit juice. Water and fat-soluble bioactive components are abundant in the juice. The sugar content of the juice is usually 4.9 percent, with fructose and sucrose being the two most common sugars. The main phenolic component is quercetin, which is followed by myricetin and kaempferol. As a result, the juice from this fruit can be a great source of healthy beverages **[6].** Minerals are considered to play a number of important roles in the body's physiology and biochemistry as enzyme co-factors, and they have an effect on fertility, mental health, and immunity **[7,8].**

[9] stated that the phenolic compounds in (*P. peruviana*) fresh fruit, researchers discovered quercetin dihydrate, catechin, rutin, epicatechin, myricetin, and kaempferol. They also looked at how catechin, ascorbic acid, -carotene, epicatechin, and hydroxyl methyl furfural (HMF) levels changed over time and at different temperatures. At 40 degrees Celsius, catechin and epicatechin levels increased**.**

(*P. peruviana*) fruits were also consumed in Chinese folk medicine and have been used to treat diabetes mellitus. According to one study, one of the mechanisms of action for this fruit's anti-hyperglycemic properties is its inhibition of the intestinal carbohydrase enzyme **[10].** Bernal **[11]** also developed a dry powder formulation of (*P. peruviana*) fruit extract in 2016 and concluded that it could be used as a potential phytotherapeutic agent for the treatment of diabetes**.** As a result, the fruit of (*P. peruviana*) may be a candidate for the production of new anti-diabetic formulations.

In-vitro models were used to assess the hypoglycemic and antihypertensive properties of native *P. peruviana* fruits in 2009. It was concluded that these foods can be effective anti-diabetic and anti-hypertensive strategies **[12].** In 2014, researchers looked into the antidiabetic ability of (*P. peruviana*) fruit in high-fat diet rats. The fruit extract was said to increase insulin sensitivity and have a major anti-diabetic effect, which was most likely attributed to the active ingredients in the extract **[13].**

The fruit's pomace was used to see whether it had any effect on hypercholesterolemia. The lipid profile of high cholesterol diet rats was investigated, and it was discovered that the pomace reduced total cholesterol, total triacylglycerol, total low-density lipoprotein cholesterol, and increased high density lipoprotein cholesterol levels. As a result, pomace intake is beneficial in general **[14].**

The purpose of this search was to see how dried goldenberry (*p. peruviana*) fruits affected diabetic rats at two different levels (5 and 10%)

2.MATERIAL AND METHODS

2.1. MATERIAL:

The goldenberry fruits (*P. peruviana* L.) were obtained from the local market at Kafrelsheikh city, Egypt.

2.2. Preparation of dried goldenberry fruits powder:

Goldenberries were selected for their size and ripening stage, then washed and dried in a solar oven. in Solar Energy Houses - Solar Energy Department - National Research Center - Dokki – Egypt at 50°C with a moisture level of less than 8%. The dry materials were milled using a moulinex mill machine until they passed through a sixty mesh screen sieve, then placed in polyethylene bags and frozen at -18 ± 2°C awaiting analysis and other usage.

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2.3. Animals:

Twenty adult male Albino rats (Sprague Dawley), (150 g±5) were obtained from the animal house of food Technology. Research. Institute, Agric, Res., Center, Giza, Egypt.

2.4. Methods:

2.4.1. Chemical composition:

The amount of crude protein, ether extract, ash, and minerals was estimated using the AOAC **[15]** methodology, whereas total carbohydrates were computed using the following formula: -

Total carbohydrates% = 100- (% crude protein + % fat + % ash).

Total carbohydrates content was calculated by difference as reported by **[16].**

Available carbohydrates were calculated by subtracting crude fibre from total carbohydrates

2.4.2. Determination of β-carotene:

β-carotene were determined according to the methods outlined in **A.O.A.C [17]**.

2.4.3. Determination of vitamin E:

Vitamin E was determined according to the methods outlined by **[18].**

2.4.4. Determination of vitamin C

Vitamin C was determined by the method of **[19]**.

2.4.5. Identification of phenolic and flavonoids compounds:

Phenolic compounds were fractionated and quantified by High Performance Liquid Chromatography (HPLC), Hewllet Packard, series1050 according to the method of **[20].** Flavonoids compounds were determined according to **[21]**

2.5. Experimental design:

In the animal house of Food Technology, a total of twenty adult male albino rats weighing (150 ± g10) were used in the current investigation. The lab rats were placed in normal healthy conditions for ten days and fed a regular food (base diet) according to the technique given by the Research Institute, Agric, Res., Center, Giza, Egypt **[22].** The rats were given free access of tap water and were fed on consistently based diet. After ten days of basal diet (adaptation period). During the G1 trial, five rats were kept as controls and fed a standard diet (normal control). After a 24-hour fast, the other 15 rats were injected with an alloxan solution (120 mg/kg body weight) for injury hyperglycemia. **[23]** Blood glucose concentration was measured three days after alloxan administration. As reported by **[24]** animals with diabetes.

The second main group (G2, G3 and G4) 15 rats was separated into three subgroups after three days of alloxan administration (5 rats each).

Table A: composition of the basal diet.

Components	g/100g diet	Components	g/100g diet
Casein	20	Salt mixture	4
Corn oil	10	Cellulose	5
Corn starch	60	Vitamins	1

2.5.1. Hyperglycemic groups:

It was separated into four groups (n=5), with one serving as a normal control group:

- **G 1 (-ve):** Rats fed on basal diet.
- **G 2 (+ve):** Rats fed on basal diet and injected via intraperitoneal with alloxan 120 mg/kg body weight.
- **G 3**: hyperglycemic rats fed on basal diet + 5% dried goldenberry.
- **G 4:** hyperglycemic rats fed on basal diet + 10% dried goldenberry.

2.6. Collection of blood sampling:

After a 12-hour fast, blood samples were obtained from the lateral tail vein eye of rats at the end of the experiment. Blood was collected into a dry, clean centrifugal tube using micro capillary glass tubes and permitted to coagulate in a water bath at room temperature for half an hour, according to **[25].** To separate the serum component for glucose testing, the blood was centrifuged for 10 minutes at 3000 rpm, and the serum was carefully transferred into transparent quit fit plastic tubes and kept frozen at (-20°C) until biochemical parameters were measured.

2.7. Glucose determination:

The level of glucose in the blood was measured using procedures outlined by **[26].**

2.8. Serum lipid analysis:

The total cholesterol and HDL levels were determined using procedures outlined by **[27]**. **[28]** were used to determine triglycerides. The levels of vLDL and LDL were calculated using the procedures outlined by **[29].**

2.9. Determination of enzymes of liver:

[30,31,32] methods were used to determine the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP).

2.10. Serum total bilirubin:

Serum total bilirubin was estimated using the procedures outlined by **[33].**

2.11. Statistical Analysis:

Duncan's multiple range tests were used for mean comparison in the statistical analysis, which was done using SPSS software (version 16).

3.RESULTS AND DISCUSSIONS

3.1. Chemical composition of golden berry (on dry weight basis).

The chemical composition of goldenberry shown in Table 1. The results obtained were based on dry weight basis. From the tabular data, it can be seen that the crude protein content of goldenberry was 9.40%. In addition to fat or ether extract 3.60%, crude fiber content 17.50%, ash 6.30%, available carbohydrates 63.20% and total carbohydrates 80.70%. These results are in contract with those attained **[34]** Goldenberry for chemical composition and they found that it contains 85.9, 1.5, 0.5, 11, 0.4 and 0.7 g /100g raw matter for moisture, protein, fat, carbohydrate, fiber and ash, respectively and 49 Cal /100g for energy.

Table 1. chemical composition of goldenberry (on dry weigh basis).

Martial used / **Constituents (%)**	**Goldenberry fruits**
Crude protein	9.40±0.03
Fat	3.60±0.01
Ash	6.30 ±0.02
Crude fibers	17.50±0.30
Available carbohydrates	63.20±0.55
Total carbohydrates	80.70±0.85

3.2. Phenolic content of golden berry.

The phenolic compounds were separated from the goldenberry and identified by High Performance Liquid Chromatography (HPLC). The results are obtainable in Table 2. Seventeen phenolic compounds have been known Rutin has been accepted as a main compound in goldenberry (75.00 mg /100g), Kampferol (45.26 mg /100g), Quercetin (25.48 mg /100g), chlorogenic acid were prevalent the phenolic compounds. The results were consistent with **[35]** as anti-diabetic agents, myrecetin, kaempferol and quercetin obtainable at various tissues. Quercetin for instance, enhances glucose uptake into skeletal muscle tissue by increasing glucose transporter 4 (GLUT4). In the liver, these agents ameliorate the glucokinase activity to increase glucose storage in the liver through activation of AMP-activated protein kinase (AMPK). AMPK is an enzyme that control the homeostatic energy in the body through

sundry mechanisms such as discouraged the gluconeogenesis, increases fatty acid oxidation, increases expression of GLUT4. In the gut, these agents help reduce the activity of maltase and glucose transporter 2 (GLUT2) which can reduce glucose uptake. **[7]**. It was found that goldenberry juice contains many phenolic substances, including quercetin as the main phenol content followed by kaempferol and myrecetin which can play a role in lowering the level of glucose in the blood.

Table 2. phenols content of goldenberry.

Phenolic compounds	**Goldenberry fruits (mg /100g)**
Epi-catachin	0.46
Gallic acid	2.64
Protocatchoic	1.90
Catechol	0.18
Salicylic acid	0.25
Catechein	8.52
chlorogenic acid	14.00
Vanillic acid	0.95
Benzoic acid	0.30
caffeine	0.22
Rutin	75.00
Ferulic acid	4.51
Iso-Ferulic acid	0.20
P-Coumaric acid	1.89
Quercetin	25.48
Kampferol	45.26
Cinnamic acid	0.27

3.3. □-carotenoids and vitamins of goldenberry (on dry weight basis).

Table 3 shown the vitamins in goldenberry. They contain higher amounts of □-carotenoids (1350 mg /100g), vitamin E (25.50 mg /g) and vitamin C (60 mg /g). **[7]** stated that goldenberry juice contained vitamin C, vitamin E, quercetin, kaempferol and myericetin. Those contents can help quercetin in goldenberry juice in improvement more preservation to β-cells as antioxidant agents compared to quercetin alone **[36]**.

Table 3. □-carotenoids and some vitamins of goldenberry (on dry weight basis).

Fruit samples	□-carotenoids mg/100g	Vitamin (C) mg/g	Vitamin (E) mg/g
Goldenberry	1350±4.5	60±3.60	25.50±1.22

3.4. Impact of goldenberry on Blood Glucose Level of Diabetic Rats

Table 4. Blood glucose levels can be obtained for diabetic groups (after 3 days of having diabetes with Alloxan) were significantly higher than the normal control (G1). The data in table 4 showed that the blood glucose level in the two groups (G3 and G4) of rats fed a basal diet supplemented with golden berry was decreased compared to diabetic rats (G2). It can be seen that the blood glucose levels decreased after 15 days of feeding until the end of the experimental period and the decrease increased with the increase in the feeding period. It is also evident from table 4 that the higher level used for golden berry (10%) resulted in more decrease in blood glucose level compared to 5%. These results are in agreement with **[37]** who reported that taking golden berry juice 1 ml/day could significantly lower blood sugar compared to the diabetes control group, golden berry was most likely influenced by the rich antioxidants contents of golden berry juice in addition to its quercetin content.

Table 4. Impact of feeding on goldenberry on blood glucose level of diabetic rats.

Rat groups	After 3 days mg/dl	After 2weeks mg/dl	After 4 weeks mg/dl	After 6 weeks mg/dl
G1	101.43^{b} ±1.55	102.00^{d} ±0.55	101.66^{d} ±1.87	98.77^{d} ±1.23
G2	304.35^{a} ±1.65	311.313^{a} ±0.85	323.23^{a} ±1.68	327.87^{a} ±1.57
G3	305.24^{a} ±1.35	274.55^{b} ±0.68	221.57^{b} ±1.64	$191.20c^{b}$ ±1.43
G4	301.03^{a} ±1.51	265.22^{c} ±1.15	208.23^{c} ±1.56	172.53^{c} ±1.56

*G1-control (-) G2-control (+) G3- 5% dried goldenberry G4- 10% dried goldenberry
*Each value is an average of five determinations
*Values followed by the same letter in column are not significantly different at $p \leq 0.05$.

3.5. Impact of goldenberry on Some Serum Lipid Parameters of Diabetic Rats

The results in Table 5. Indicated that TC, triglycerides, LDL-c cholesterol and VLDL-c in the groups G3, and G4 of rats that fed on basal diet supplemented with golden berry decreased, while HDL-c cholesterol increased compared to diabetic control rats (G2). These

results are agreeing with **[38]**. Goldenberry improve the lipid profile of rats with high lipid levels when fed goldenberry.

Table 5. Impact of goldenberry on some lipid parameters of normal and diabetic rats.

Treatment	T. cholesterol mg/dl	Triglyceride mg/dl	HDL mg/dl	LDL mg/dl	VLDL mg/dl
G1	110.71^{d} ±2.27	102.70^{d} ±3.34	70.59^{a} ±1.72	19.58^{d} ±2.46	20.54^{d} ±0.79
G2	188.00^{a} ±1.56	178.05^{a} ±3.21	38.29^{d} ±2.15	114.10^{a} ±2.33	35.61^{a} ±0.67
G3	134.47^{b} ±3.65	132.80^{b} ±2.42	54.89^{c} ±1.36	53.02^{b} ±4.25	26.56^{b} ±0.76
G4	116.94^{c} ±3.22	114.20^{c} ±2.96	66.75^{b} ±1.45	27.35^{c} ±3.23	22.84^{c} ±0.85

*G1-control (-) G2-control (+) G3- 5% dried goldenberry G4- 10% dried goldenberry
* Each value is an average of five determinations.
*Values followed by the same letter in column are not significantly different at $p \leq 0.05$.

3.6. Impact of golden berry on Liver Function of Normal and Diabetic Rats

Table 6 showed that liver functions ALT, AST, ALP and Bilirubin activity were significantly increased for the diabetic control rats (G2) compared with normal control rats (G1). The diabetic rats fed on basal diet supplement with golden berry showed decreased liver functions compared to diabetic control rats (G2). These results were in the same line with **[39]** found that the activities of serum AST, ALT and ALP in diabetic rats showed significant increasing as compared with control group. Oral supplemented of goldenberry extract to diabetic rats significantly normalized the differed levels in comparison with control group.

Table 6. Influence of feeding golden berry on liver functions in rats

Treatment	ALT (U/L)	AST (U/L)	ALP (U/L)	Bilirubin (mg/dl)
G1	36.11^{d} ±1.23	37.78^{c} ±1.24	74.67^{d} ±2.08	0.285^{c} ±2.13
G2	65.45^{a} ±1.43	87.11^{a} ±2.23	116.33^{a} ±0.54	0.593^{a} ±2.43
G3	55.78^{b} ±2.23	74.45^{b} ±1.43	103.43^{b} ±1.15	0.454^{b} ±1.43
G4	52.11^{c} ±0.45	72.79^{b} ±1.65	95.79^{c} ±1.53	0.388^{d} ±2.35

* G1-control (-) G2-control (+) G3- 5% dried goldenberry G4- 10% dried goldenberry
* Each value is an average of five determinations.

* Values followed by the same letter in column are not significantly different at $p \leq 0.05$.

4.Conclusion

The data revealed that adding the hyperglycemic-producing diets with the additive dried goldenberry fruits had significant reduction in serum glucose, lipid profile (cholesterols, triglyceride, LDL and vLDL-cholesterol). Meanwhile, HDL cholesterol increased with all treatments, significant decrease in ALT, AST, ALP, and total bilirubin values, in respect to positive control. In conclusion, the incorporation of low-cost natural sources of bioactive material into our low-cost meals for the treatment or prevention of our widespread disease is an innovative road to making low-cost therapeutic foods accessible to a broad range of our people.

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