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RESEARCH ARTICLE

Red beetroots - a potential dietary supplement in the management of hypercholesterolemia

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Abstract

Red beetroot juice was studied for its potential antihypercholesterolemic effects in cholesterol-rich diet-induced hypercholesterolemia. Thirty healthy adult albino rats were freely divided into two major groups, the first of which was fed on a baseline diet only (control negative: 6 rats), and the second of which was provided a hypercholesterolemic diet (24 rats) for 4 weeks. Chemical composition of red beetroots (ash, crude fats, crude proteins, crude fiber, carbohydrates, phenolic and flavonoids compounds) and mineral content were estimated, in addition to lipid profile and glucose levels were evaluated in the tested rats blood serum. The results showed that, levels of total cholesterol and triglycerides in hypercholesterolemic rats increased significantly, while the levels of high-density lipoprotein-cholesterol (HDL-C) decreased significantly. After fed on red beetroot juice (at the doses of 200, 400 and 600 mg/kg/day for 4weeks), total cholesterol and triglycerides were significantly lowered, whereas HDL-C was significantly elevated. According to our data, red beetroots appeared to have considerable antihypercholesterolemic and antioxidant properties, as well as the phytoconstituents (e.g. flavonoids and phenolic acids) of beet root may have free radical scavenging effects. As a result, these findings open the way for the use of bio-waste from the food sector.

Keywords: beetroot; cholesterol; hypercholesterolemic; glucose; rats.

1. Introduction

The well-documented nutritional benefits of diets rich in fruits and vegetables, have prompted a rise in interest in "functional foods" and their use in health and disease. Vegetables are varying greatly in nutrients content, they are not a major source of carbohydrates compared to starchy foods, which make up the majority of food consumed, but they do contain vitamins, essential amino acids, minerals, and antioxidants (Zhou *et al.*, 2009). Recent research suggests that various vegetables and herbs, in addition to decreasing cholesterol, can also prevent the formation of reactive oxygen species, develop resistance of plasma lipoprotein to oxidation, which may contribute to their efficiency in avoiding atherosclerosis (Kim *et al.*, 2003; Ou *et al.*, 2006; Rosenson, 2004). Hypercholesterolemia is very well risk factor for atherosclerosis and, as a result, coronary heart disease. In the United States, Europe, and most parts of Asia, cardiovascular disorders are the major cause of death (Braunwald, 1997; Khoo *et al.*, 2003). Hypercholesterolemia is known to enhance the formation of reactive oxygen species (Prasad and Kalra, 1993; Gökkuşu and Mostafazadeh, 2003), which may have a major role in the development and/or aggravation of cardiovascular disorders (Dhalla *et al.*, 2000; Wu *et al.*, 2002). *Beta vulgaris* is a member in the Chenopodiaceae family. It is distinguished by its several cultivars, the most well-known of which is the purple root vegetable called as beetroot or table garden beet. Beetroot can be consumed fresh, cooked, boiled, or utilized to extract juice. Red beets are wonderful roasted, pickled, in

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salads, or in soup, as they are in many Eastern and Central European nations (Babarykin *et al.,* 2019), and extensively used in industry as a foodstuff colouring ingredient called E162 (Zielińska-Przyjemska *et al.,* 2009; Georgiev *et al.*, 2010). The recent study in beetroot has been driven by the revelation that sources of dietary nitrate may have crucial consequences for maintaining cardiovascular health (Lundberg *et al.,* 2008). On the other hand, beetroot contains a number of additional bioactive chemicals that may have health advantages, particularly in conditions characterized by chronic inflammation. Moreover, beetroot juice has a high concentration of biologically available antioxidants, in addition to many other health-promoting ingredients like potassium, magnesium, folic acid, iron, zinc, calcium, phosphorus and sodium (Wootton-Beard *et al,* 2011). Furthermore, Beetroot juice is of particular importance since it is an abundant source of several polyphenolic components (Kaur and Kapoor, 2002; Pitalua *et al.,* 2010). The aim of this study was to investigate the red beetroot properties to protect rats from hyperlipidemia caused by a cholesterol-rich diet, in order to support the claims of its traditional use to lower total cholesterol.

2. Materials and methods

2.1. Plant Material and juice preparation

The red beetroots were purchased from local market in Assiut, Egypt. Red beets were peeled and sliced into pieces after being cleaned under running water. After that, juice was extracted using a "Kenwood electric juice extractor."

2.1.1. Chemicals

Cholesterol, vitamins, casein, cellulose, minerals, choline bitartrate and DL-Methionine were obtained from El-Gomhoria Company for Chemicals and Drugs, Assiut, Egypt.

2.1.2. Animals

30 male albino rats (150-200g) weigh were gotten from the Faculty of Medicine, Assiut University, Egypt.

2.2. Chemical composition of red beetroots

Red beetroots were sliced and dried to estimate moisture, then ground to determine crude protein, ash, crude fat and crude fiber contents according to official methods (AOAC, 2000) in Agricultural Research Center, Cairo Egypt. The results were an average of three replicates. Carbohydrate contents were calculated by difference. according to (Turhan *et al.,* 2005)

2.2.1. Minerals determination

Dried red beetroots were ground then minerals (Na, K, Ca, Fe and Mn) were estimated using atomic absorption spectrophotometry (Perkin-Elmer, Model 2380, USA) according to the methods of Chapman and Pratt (1982). While, Zn was determined based on dry weight in red beetroots according to the methods of AOAC (2000).

2.2.2. Phenolic and flavonoids compounds identification.

High Performance Liquid Chromatography (HPLC) was used to fractionate and identify phenolic chemicals in dried red beetroots according to the method of Goupy *et al.* (1999), while flavonoids compounds in dried red beetroots samples were estimated according to Mattila *et al.* (2000).

2.3. Experimental Design

Healthy 30 male albino rats (150-200g) weigh were placed in metal cages and kept at a consistent temperature (22°C), humidity (55%), and 12 h. light-dark cycles. After the adaption stage, 30 rats were randomly divided into 2 groups, the first of which was fed a basal diet only (control negative: 6 rats each (group I)), and the second of which was provided a hypercholesterolemic diet (24 rats) table 1, according to Wang *et al.* (2010) for 4 weeks to increase lipid level in blood. Hypercholesterolemic group subdivided into 4 groups as a following:

Group II: control positive fed with hypercholesterolemic diet.

Group III: fed with hypercholesterolemic diet plus beet rot (Juice) 200 mg/kg/day per orally.

Group IV: fed with hypercholesterolemic diet plus beet rot (Juice) 400 mg/kg/day per orally.
Group V: fed with hypercholesterolemic diet plus beet rot (Juice) 600 mg/kg/day per orally.
After 4 weeks, Rats were starved for one night before being sacrificed and blood was taken and centrifuged. Separated serum was kept at -20°C until analysis (Olumese and Oboh, 2018).

2.4. Biochemical analysis of rats blood

Blood samples were obtained from rats that had been starved overnight. Total cholesterol (TC) (Richmond, 1973), triglycerides (TG) (Wahlefeld, 1974), and high-density lipoprotein (HDL-c) (Albers *et al.*, 1983) levels in the blood were measured using the procedures described. However, the following equation was used to determine low density lipoprotein (LDL-c) according to (Fridewald et al., 1972):

LDL-c = TC - (HDL-c + VLDL-c)

Very low-density lipoprotein (VLDL-c) was also calculated using the following equation (Fridewald *et al.*, 1972): VLDL-c= TG/5. Moreover, the fasting blood glucose levels were measured from tail blood samples by using a OneTouch Ultra® glucometer.

Table 1. Composition of the diets (g/100gm of diet)

	Control	hypercholesterolemia
Casein(g)	20	20
Starch(g)	15	15
Vitamin mixture(g)	1	1
Mineral mixture(g)	3.5	3.5
Choline bitartrate(g)	0.2	0.2
Cellulose(g)	5	5
DL-Methionine(g)	0.3	0.3
Corn oil(g)	10	10
Sucrose(g)	45	43.75
Cholesterol(g)	0	1
Bile salt (g)	0	0.25
Total(g)	100	100

2.5. Statistical analysis

Statistical analysis was carried out using SPSS version 26. Descriptive statistics such as (means and standard deviation) was calculated.

3. Result

3.1. The chemical composition of red beetroot

The chemical composition of red beetroot is documented in table 2. Red beetroot was found to be a good source of carbohydrates, crude fat, crude protein, crude fiber, and ash, according to the finding.

Table 2. Chemical composition of red beetroots as Av±SD (based on dry weight)

Parameter %	Av±SD
Moisture	85.8±1.2
Crude protein	1.86±2.2
Crude fat	0.5±1.4
Ash	1.44±1.6
Crude fiber	1.9±2.4
Carbohydrates	8.5±2.5

3.2. Minerals constituents of red beetroots

The date in table 3 illustrated that red beetroot is rich in certain minerals such as Na, K, Ca, Fe, Mn and Zn.

3.3. Phenolic compounds and flavonoid compounds of red beetroot

High Performance Liquid Chromatography (HPLC) was used to separate and identify phenolic and flavonoids components in red beetroot, and the findings are displayed in Table (4). A total of fourteen phenolic and flavonoid compounds were found. The main dominant components found were Chlorogenic acid (675.25 µg/g), Gallic acid (262.77 µg/g), Querectin (31.65 µg/g), Syringic acid (18.65 µg/g), Coffeic acid (16.98 µg/g), Daidzein (15.10 µg/g). While, Naringenin, Methyl gallate, Ferulic acid, Rutin, Coumaric acid, Catechin, Cinnamic acid and Vanillin ranged from 10.81 µg/g to 2.88 µg/g.

Table 3. Minerals content of red beetroots samples based on dry weight

Minerals	Content (mg/100g)
Sodium (Na)	68.5
Potassium (K)	32.1
Calcium (Ca)	12.9
Iron (Fe)	0.90
Manganese (Mn)	078
Zinc (Zn)	0.24

Table 4. Phenolic and flavonoids compounds (µg/g) of red beetroot samples based on dry weight

Phenolic Compound	Conc. (µg/g)	Flavonoids Compound	Conc. (µg/g)
Gallic acid	262.77	Catechin	6.08
Chlorogenic acid	675.25	Naringenin	10.81
Vanillin	2.88	Daidzein	15.10
Methyl gallate	8.91	Querectin	31.65
Coffeic acid	16.98	Rutin	8.53
Syringic acid	18.65		
Ferulic acid	8.71		
Coumaric acid	6.21		
Cinnamic acid	3.71		

3.4. Effect of red beetroots extract on serum lipid profile of the experimental rats

When compared to control rats, rats fed a cholesterol-rich diet developed hypercholesterolemia and hyperlipidemia, with higher total cholesterol (TC), triglyceride (TG) levels, LDL-C and a substantial reduction in HDL-C levels. However, rats groups treated with beetroots juice (200, 400 and 600 mg/kg b.w.) revealed a significant decrease in total cholesterol, triglycerides, LDL-C and a significant increase in HDL-C levels (table 5).

Table 5. Effect of red beetroot juice on serum lipid profile and glucose levels as Av±SD in induced hypercholesterolemia rats

Group No.	Glucose (mg/dL)	Cholesterol (mg/dL)	Triglycerides (mg/dL)	HDL-C (mg/dL)	LDL-C (mg/dL)	VLDL-C (mg/dL)
Group I	73.5±4.1	82.2±4.3	86.1±2.1	45.1±3.8	19.88	17.22±2.1
Group II	85±3.2	180.1±2.8	168±3.5	26.8±2.5	119.7	33.6±2.2
Group III	80±1.2	130.4±1.4	115±2.6	35.1±1.7	72.3	23±2.1
Group IV	76±4.2	99.8±3.5	91.2±4.1	42.1±2.8	39.46	18.24±1.4
Group V	72.2±1.8	86.2±3.4	82.5±1.4	46.8±2.5	22.9	16.5±1.6

3.5. *Effect of red beetroot juice on blood glucose levels of the tested rats*

In comparison to control rats, rats fed a cholesterol-rich diet showed no significant change in serum glucose levels. In addition, blood glucose levels in the treatment groups with beetroots juice (200, 400 and 600 mg/kg b.w.) were not significantly different from those in the hypercholesterolemic group (table 5).

4. Discussion

Beetroot and its products provide a variety of potential health benefits. It contains 85.8% moisture, 1.68% crude protein, 0.5% crude fat, 1.44% ash,1.9% crude fiber and 8.5% available carbohydrates. These findings are similar to those of Kale *et al*. (2018). As well as, the beetroot has abundant of certain minerals as sodium 68.5, potassium 32.1, calcium 12.9, iron 0.9, manganese 0.78, zinc 0.24 mg/100g. This finding is in the line with Kale et al. (2018).

The red beetroot juice had a total phenolic concentration of 217.9 mg/g. This result is consistent with the ideas of (Shyamala and Jamuna, 2010). Phenolics are one of phytochemicals group and have been responsible for the majority of plant (or) plant product antioxidant activity. Antioxidant nutrients have been shown to help fight oxidative stress in a variety of conditions, including cancer, cardiovascular disease, and neurological disorders (Ferrari and Torres, 2003; Ferrari, 2004).

Our result investigated the beetroot juice for its potential antihypercholesterolemic properties. Rats fed on a high-cholesterol diet had an increase in total cholesterol and triglycerides in their blood, as well as a drop in circulating HDL-C and a rise in LDL-C. These results are in agreement with studies Ashraf *et al.* (2005) and Chen *et al.* (2002). A higher plasma LDL-C level is linked to more cholesterol accumulation in the arteries and aorta, raising the risk of coronary heart disease (Ramakrishnan, 1994), whereas low HDL-C is the most commonly observed abnormal lipoprotein (Gupta *et al.*, 1994; Gupta *et al.,* 1995). In the current study, beetroot treatment reduced total cholesterol and triglycerides while increasing HDLC levels, implying that beetroot has cardioprotective and lipid-lowering properties. This lipid-lowering ability of beet root could be attributed to the phytoconstituents (e.g. flavonoids and phenolic acids) of beet root may have free radical scavenging effects and reduce oxidative damage (Shimada *et al.*, 2007). These findings are consistent with previous research that has shown the influence of flavonoids on cholesterol metabolism (Cheeke, 1971). Flavonoids are also active components in a variety of therapeutic plants (Wollenweber, 1988), as well as natural goods that have a positive impact on human health (Das and Ramanathan, 1992). Similarly, Singh *et al.* (2015) found that beetroot juice drinking reduced total cholesterol, LDL, and triglyceride levels while also increasing HDL levels considerably. In the same manner, Clifford *et al.* (2015) found that beetroot reduced cholesterol and oxidised LDL cholesterol, which helped to maintain the vascular system and manage cardiovascular disease. Red beetroot consumption, according to Ninfali and Angelino (2013) has a positive physiological effect on atherosclerotic disease. This was attributable to the high concentration of betalains, which lowered homocysteine levels and maintained vascular homeostasis (Amin et al., 2020).

5. Conclusions

Based on the evidence, beetroot appears to be a potent nutritional source of care substances with therapeutic potential for a variety of pathological conditions. Moreover, the current research establishes a basic scientific foundation for the hypolipidemic properties of beetroot, a plant that has long been employed in folk medicine.

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Authors' Contributions

Equal contribution for all authors.

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

The data sets generated and/or analyzed during the current study are not publicly available due to the rules of our institutes but are available from corresponding author on reasonable requests.

Ethics Approval and Consent to Participate

The Animal Ethical Committee for Research of Faculty of Science, Al-Azher University, Assiut branch, Egypt gave its clearance to the current study. All studies were carried out in conformity with the Animal Ethical Committee for Research of Faculty of Science, Al-Azher University, Assiut branch, Egypt's rules and regulations.

Consent for Publication

All authors approved this research article to be published in (SVU-international journal of agricultural science.

Conflicts of Interest

The authors declare no conflict of interest.

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