The therapeutic effect of some tuber plants that found in the Al- Baha area on bio-chemical changes in hyperglycemic rats

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Abstract: Background: Leafy vegetables are among the most nutritious vegetables on a fresh weight basis and are also among the world's most productive plants in terms of nutritional value per unit area, in part because they grow rapidly, allowing several crops or harvests in a season **Objective**: This investigation aims to therapeutic effects of vegetable growths (green onground parts) of tuberous plants such as greens of taro, carrot, suger beet, sweet potato, and potato leavesand stem are scant. **Design**: Thirty-five rats Sprague Dawley white male albino rats, weighing about 150 ± 10g were used in the study. The experiment was performed in Animal House. All rats were fed for one week on basal diet before starting the experiment, then divided into two main groups, the first group (n= 5 rats) was fed on the basal diet only as a control negative (C –ve) normal rats for 28 days. The rats of second main group (n= 30 rats) were injected alloxan. The obtained data were statistically analyzed using computerized SPSS **Results**: Hyperglycemic rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stems 5% recorded significant decrease in Serum GPT compared to control (+ve) Hence there was a significant increase in control (+) compared to control (-) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5 % denoted significant decreases in serum glucose compared to control (+)). Diabetic rats fed on taro, carrot sugar beet, sweet potato and potato leaves and stems 5% diet denoted significant decreases in U.acid compared to control (+ve) rats, **Recommendation**: This study suggested to use vegetable greens of tuberous plants, namely that of taro, carrot, sugar beet, sweet potato and potato for hyperglycemic patients

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Introduction

Leafy vegetables are among the most nutritious vegetables on a fresh weight basis and are also among the world's most productive plants in terms of nutritional value per unit area, in part because they grow rapidly, allowing several crops or harvests in a season. Although some of the constituents are lost during cooking, they still contribute significant amounts of provitamins A and C and several minerals. Leafy vegetables are also good for the eyes. Age-related macular degeneration is a leading cause of blindness among individuals over the age of 50. A research study in Massachusetts found that people who ate spinach, collards, and other dark green, leafy vegetables five or six times a week had about a 43 percent lower risk of the disease than those who ate it less than once a month. The typical shelf life for most leaf vegetables is ten to fourteen days. **(Lee *et al., 2008).* In 2000,** according to the World Health Organization, at least 171 million people worldwide suffer from diabetes, or 2.8% of the population. Its incidence is increasing rapidly, and it is estimated that by 2030, this number will almost double. Diabetes mellitus occurs throughout the world but is more common (especially type 2) in the more developed countries. The greatest increase in prevalence is, however, expected to occur in Asia and Africa, where most patients will probably be found by 2030. **(Pignone *et al*, 2010).** The increase in incidence of diabetes in developing countries follows the trend of urbanization and lifestyle changes, perhaps most importantly a "Western-style" diet. This has suggested an environmental (i.e., dietary) effect, but there is little understanding of the mechanism (s) at present, though there is much speculation, some of it most compellingly presented. **(Wild *et al,* 2004).**

- Aim of study

Identification of the therapeutic effect of some tuberous plants found in al-Baha area on bio-chemical changes in hyperglycemic rats- *Materials and Methods.*

1- Materials

1.1. Plants

Preparation of vegetable greens of tuberous plants: The plants which used to obtain leaves and stems were:

1. Colocasia esculenta, schott, (Taro), family (Araceae).
2. Beta vulgaris, L, (Sugar beet), family (Chenopodiaceae).
3. Daucus carota var. sativa, (Carrot), family (Umbelliferae).
4. Ipomoea batato, Lam. (Sweet potato), family (Convolvulaceae).
5. Solarium tuberosum, L. (Potato), family (Solanaceae).

Leaves and stem of above noted plants obtained fresh from field and cleaned thoroughly by washing. Then, they were sun dried and milled. thoroughly by washing. Then, they were dried and milled 1.2. Diets.

1.2.1. Basal Diet

The basal diet was prepared according to **Reeves et al., (1993).** It was consisted of 20% protein (casein), 10% sucrose, 4.7% corn oil, 2% choline chloride, 1% vitamin mixture, 3.5% salt mixture and 5% fiber (cellulose). The remainder was corn starch as it was recorded in tables (a-c).

Table (a): The composition of basal diet

Compounds	Amount
Protein	20%
Corn oil	4.7 %
Salt mixture	3.5 %
Vitamin mixture	1 %
Cellulose	5 %
Choline chloride	2 %
Sucrose	10%
Corn starch	Up to 100%

Source: Reeves et al., (1993).

Table (b): The composition of salt mixture (g/100g):

Compounds	Amount
$CaCO_3$	600 mg
K_2HPO_4	645 mg
$CaHPO_4.2H_2O$	150 mg
$MgSO_4.2H_2O$	204 mg
NaCl	334 mg
Fe $(C_6H_5O_7)26H_2O$	55 mg
Kl	1.6 mg
$MnSO_4.4H_2O$	10 mg
$ZnCl_2$	0.5 mg
$CuSO_4.5H_2O$	0.06 mg

Source: (Hegsted et al., 1941).

Table (c): The composition of vitamin mixture

Vitamin	Amount
Vitamin E	10 Iu
Vitamin K	0.50 Iu
Vitamin A	200 Iu
Thiamin	0.50 mg
Pyridoxine	1.00 mg
Niacin	4.00 mg
Calcium panthothenic acid	0.40 mg
Vitamin D	100 Iu
Choline chloride	200 mg
Folic acid	0.02 mg
Inositol	24 mg
Para-amino – benzoic acid	0.02 mg
Vitamin B_{12}	2.00 µg
Biotin	0.02 mg

Source**: (Campbell, 1963).**

1.2.2. Experimental diet

Experimental diet prepared from basal diet plus the powdered plants added at a percentage of 5% and is shown in table (d).

Table (d): The composition of basal and Experimental diet:-

Component (g)	Basal diet	5% taro leaves and stem	5% carrot leaves and stem	5% sugar beet leaves and stem	5% sweet potato leaves and stem	5% potato leaves and stem
Test ingredients	---	**5**	**5**	**5**	**5**	**5**
Casein	**20**	**20**	**20**	**20**	**20**	**20**
Corn oil	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**
Mineral mix	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**
Vitamin mix	**1**	**1**	**1**	**1**	**1**	**1**
Cellulose	**5**	**5**	**5**	**5**	**5**	**5**
Cholin chloride	**2**	**2**	**2**	**2**	**2**	**2**
Sucrose	**10**	**10**	**10**	**10**	**10**	**10**
Corn starch	**Up to 100**	**Up to 100**	**Up to 100**	**Up to 100**	**Up to 100**	**Up to 100**

1.3. Diabetic rats

Diabetes was induced in normal healthy male albino rats by intra- peritoneal injection of alloxan 150 mg/kg body weight, according to the method described by (**Desai and Bhide, 1985).** One week after obtained were samples blood the injection of alloxan, fasting to estimate fasting serum glucose. Rats having fast serum glucose more than 190 mg/dl were considered diabetics **(NDDG, 1994).**

1.4. Rats

Thirty-five rats Sprague Dawley white male albino rats, weighing about 150 ± 10g were used in the study. The animals were obtained from Helwan Experimental Animals Station. Rats were housed in wire cages under the normal laboratory condition and fed on basal diet for a week as adaptation period. Diet was given in non- scattering feeding cups to avoid loss or contamination of food, water was provided to the rats by means of glass tubes projecting through the wire cage from an inverted bottle supported to one side of the cage.

2- Methods

2.1. Preparation of plant

The plant materials were grinded in a mixer to give a powder and were kept in dusky stoppered glass bottles in a cool and dry location till use, according to Russo (2001), who reported that all herbs and plants are best kept in a cool, dry and dark location to reduce oxidation of their contents.

2.2. Grouping and feeding of rats

The experiment was performed in Animal House. All rats were fed for one week on basal diet before starting the experiment, then divided into two main groups, the first group (n= 5 rats) was fed on the basal diet only as a control negative (C –ve) normal rats for 28 days. The rats of second main group (n= 30 rats) were injected alloxan. The rats were divided into 7 groups each of 5 rats. The groups of rats were as follows:

Group (2): Hyperglycemic control positive group, in which alloxan injected rats fed on basal diet (control "+").

Group (3): Hyperglycemic group fed on basal diet + taro leaves and stem 5%.

Group (4): Hyperglycemic group fed on basal diet + carrot leaves and stem 5%.

Group (5): Hyperglycemic group fed on basal diet + sugar beet leaves and stem 5%.

Group (6): Hyperglycemic group fed on basal diet + sweet potato leaves and stem 5%.

Group (7): Hyperglycemic group fed on basal diet + potato leaves and stem 5%. Induction of liver intoxication in rats.

Thirty five rats Sprague Dawley white male albino rats, weighing about 150 ± 10g were used in the study. The animals were obtained from Helwan Experimental Animals Station. Rats were housed in wire cages under the normal laboratory condition and fed on basal diet for a week as adaptation period. Diet was given in non- scattering feeding cups to avoid loss or contamination of food, water was provided to the rats by means of glass tubes projecting through the wire cage from an inverted bottle supported to one side of the cage.

2.3. Blood sampling

At the end of the experiment period (28 days) rats were sacrificed by ether an anesthesia. Blood samples were obtained by retro-orbital method in a clean dry centrifuge tube. They were left to clot by standing at room temperature for 20 minutes, and then centrifuged at 1500 r.p.m for 15 minutes. Serum samples were collected by a dry clean syringe, poured in Wisserman tubes and then kept frozen in a refrigerator at -10ºC till biochemical analysis. Rats were thereafter opened, liver, spleen, heart, lungs and kidneys removed and washed in saline solution, then dried and weighted. Relative weights of mentioned organs were calculated using the following formula.

$$\text{Relative organ weight} = \frac{\text{Organ weight}}{\text{body weight}} \times 100$$

For fixation prior to histopathological investigation, organs were kept in formalin solution (10% V/V) according to methods described by **Drury and Wallington (1967**).

2.4. Biological Evaluation

During the period of the experiment, all rats were weighed once a week and the consumed diets were recorded everyday (daily food intake). At the end of the experiment, biological evaluation of the experimental diets was carried out by determination of body weight gain% (BWG%) and food efficiency ratio (FER). According to **Chapman *et al*., (1959),** using the following formulas: -

$$\text{BWG \%} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

$$\text{FER} = \frac{\text{Body weight gain (g)}}{\text{Food Intake (g)}}$$

2.5. Biochemical Analysis

At the end of experiment of period blood samples were collected after 12 hours fasting from the portal vein; the rats were scarificed after being ether anesthetized. Blood samples were received into clean dry centrifuge tubes, and left to clot at room temperature, then centrifuged for 10minutes at 3000 rpm to separate the serum.

Serum was carefully aspirated and transferred into clean cuvet tubes and stored frozen at 20 o C for analysis **(Malhotra, 2003)**. All serum samples were

analyzed for determination the following parameters: Plasma total protein, plasma albumin, alkaline phosphatase, glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), uric acid, creatinine, urea, triglyceride (T.G), total cholesterol (T.C), HDL, glucose, VLDL = T.G /5,

LDL = [T.C – (HDL +VLDL)]. At the same time, the organs: Heart, lungs, liver, spleen, and kidneys removed, cleaned, weighted, and stored in formalin solution (10 %) for histopathological investigation as the method mentioned by **Drury and Wallington (1980).**

Determination of liver function }total protein, albumin, alkaline phosphates (ALP), Glutamic Oxaloacetic Transaminase (GOT) and Glutamic pyruvic Transaminase (GPT)}, kidney function (urea, uric acid and creatinine). total lipids (total cholesterol, triglycerides, HDL, serum glucose:

1. Total protein was determined by Biuret method according to the method described by **Weichselbaum, 1964).**

2. Albumin was determined in serum according to the method described by **Doumas and Biggs (1971).**

3. Determination of alkaline phosphatase (ALP) was carried out by kinetic method according **to Rec. (1972).**

4. Determination of SGOT was carried out as follows Glutamic + Oxaloacetic Transaminase ά ketoglutaric acid +Aspartic acid according to **Reitman and Frankel (1957).**

5. Determination of SGPT was carried out as follows Glutamic + oxaloacetic Transaminase ά ketoglutaric acid + Alanine according to **Reitman and Frankel (1957).**

6. Determination of uric acid was carried out by enzymatic colorimetric method according to **Fossati (1982).**

7. Determination of creatinine was carried out by colorimetric method according to **Henry (1974).**

8. Determination of urea was achieved by enzymatic method according **Patton (1977).**

9. Determination of triglycerides was carried out by enzymatic colorimetric test according to **Trinder (1969).**

10. Determination of HDL- cholesterol was carried out according to **Rhichmond (1973).**

11. Determination of Cholesterol was carried out by enzymatic colorimetric test (CHOD-PAP) according to **Rhichmond (1973).**

12. Calculation of LDL cholesterol and VLDL cholesterol **Friede wald et al., (1972).**

13. Very low-density lipoprotein (VLDL cholesterol) = Triglycerides /5. LDL cholesterol =Total cholesterol – (HDL cholesterol + VLDL cholesterol). Calculation of Atherogenic index: This index was calculated as the VLDL + LDL cholesterol / HDL ratio according to the formula of **Kikuchi-Hayakawa et al., (1998).**

14. Determination of glucose was carried out by enzymatic colorimetric method according to **Trinder (1969).**

5- Histopatlioiogical examination

Specimens from (liver and heart) were collected from, studied rats by the end of experimental period, fixed in 15 % neutral buffered formalin (PH 7.0) (**Drury and wallington, 1980)**, dehydrated in ethyl alcohol, cleared in xylol and embedded in paraffin. 6 mM sections were prepared and stained with Hematoxylins and Eosin (**Carleton, 1976).**

6. Statistical analysis

The obtained data were statistically analyzed using computerized SPSS (Statistic Program Sigmastat, statistical soft-ware, SAS Institute, Cary, NC). Effects of different treatments were analyzed by one-way ANOVA (Analysis of variance) test using Duncan's multiple range test and $p<0.05$ was used to indicate significance between different groups, the following formulas were used **(Snedecor and Cochran, 1967).**

Results And Discussion

1- Biological Results:

1.1. Effect of on ground green growths on body weight gain (B. W. G.), food intake (F. I.), and food efficiency ration (F. E. R.).

Data listed in table (1) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on B. W. G., F. I., F. E. R., of hyperglycemic rats.

These results denote that in control (-ve) normal rats body weight gain B. W. G. was 81.75±2.50 g while in control (+ve) diabetic rats injected by alloxan without treatment was 24.45±1.84 g. These results indicated a significant decrease in control (-ve) B. W. G compared to control (+ve) groups. Diabetic rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stem recorded significant increase compared to control (+ve) which were 50.0±1.96, 46.25±1.09, 38.75±1.95, 53.0±2.49, and 29.0±1.68 g respectively.

Concerning food intake (F. I.): Data of table (1) showed that in control (-ve) normal rats food intake (F. I.) was 16.13±0.81 g, While in control (+ve) diabetic rats injected with alloxan without treatment it was 14.0±0.92 g. These results revealed significant decrease in control (+ve) compared to control (-ve). Diabetic rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stem 5% reflected significant increase compared to control (+ve) group, values were 15.03±0.44, 30.9±1.31, 38.71±1.76, 26.77±0.38, 17.59±0.69 g respectively.

As for the food efficiency ratio (F. E. R.): it could be observed that in control (-ve) normal rats food efficiency ratio (F. E. R.) was 0.18±0.03, while in control (+ve) diabetic rats without treatment it was 0.073±0.009. These results reflected significant decrease in control (+) compared to control (-ve) group. Diabetic rats fed on taro leaves and stem 5% diet showed significant increase compared to control (+ve), but in diabetic rats fed on carrot, sugar beet, and potato leaves and stem 5% showed significant decreases compared to control (+), which were 0.065 ± 0.024, 0.033 ± 0.012, and 0.053 ± 0.032 respectively. On the other hand, diabetic rats fed on sweet potato leaves and stem 5% revealed non-significant changes compared to potato leaves & stem diet which were 0.07 ± 0.008, and 0.053 ± 0.032 respectively. data of table (1) were in line with that found by Ahmed, Reham (2007) working with the effect of plants on hyperglycemic rats.

Table (1): Effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on B. W. G., F. I., F. E. R. of hyperglycemic rats.

Parameters / Groups	B. W. G. (g)	F. I. (g)	F. E. R.
Control (-ve)	81.75±2.50[a]	16.12±0.81[d]	0.18±0.030[a]
Control (+ve)	24.45±1.84[f]	14.0±0.92[f]	0.073±0.009[d]
Taro leaves and stem 5%	50.0±1.96[b]	15.03±0.44[e]	0.115±0.003[b]
Carrot leaves and stem5%	46.25±1.09[c]	30.9±1.31[b]	0.065±0.024[c]
Sugar beet leaves and stem 5%	38.75±1.95[d]	38.71±1.76[a]	0.033±0.012[d]
Sweet potato leaves and stem 5%	53.0±2.49[b]	26.77±0.38[c]	0.07±0.008[c]
Potato leaves and stem 5%	29.0±1.68[e]	17.59±0.69[d]	0.053±0.032[c]

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1.2. Effect on relative organs weight:

Data listed in table (2) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on relative organs weight of hyperglycemic rats.

1.2.1. Relative weight of liver:

Data presented in table (2) showed that for control (-ve) normal rats liver (%) was 3.68±0.3%, while in control (+ve) diabetic rats (hyperglycemic rats) without treatment was 4.15±0.14%. These results denote that there was a significant increase in control (+ve) compared to control (-ve) liver %. Alloxan injected rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stem 5% diets recorded significant decrease of liver % compared to control (+ve) group, values were 3.40±0.08, 3.19±0.06, 3.99±0.19, 3.24±0.21, and 3.73±0.19% respectively. These vegetable greens of tuberous plants seem to correct the liver inflammation.

1.2.2. Relative heart weight:

Data of table (2) showed that for control (-ve) normal rats heart % was 0.35±0.03%, while for control (+ve) diabetic rats without treatment it was 0.42±0.02%. These results denote that there was significant increase in control (+ve) rats compared to control (-ve) group. Hyperglycemic rats and fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stems 5% observed significant decrease compared to control (+ve) group which were 0.39±0.03, 0.38±0.02, 0.39±0.04, 0.37±0.04, 0.37±0.02% respectively.

1.2.3. Spleen relative weight:

The obtained results showed that in control (-ve) normal rats spleen % was 0.44±0.05, while in control (+ve) hyperglycemic rats without treatment it was 0.48±0.02% indicating inflammation. These results reflected that there was a significant increase in control (+ve) rats spleen % compared to control (-ve). Hyperglycemic group fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stems 5% reflected significant decrease of spleen % compared to both control (+ve) & control (-ve), values were 0.36±0.04, 0.35±0.02, 0.42±0.01, 0.4±0.04, and 0.38±0.03% respectively.

1.2.4. Relative kidney weight:

The results of table (2) revealed that in control (-ve) normal rats kidney % was 0.73±0.06, while in control (+ve) hyperglycemic rats without treatment it was 0.69±0.02% indicating atrophy. Results denoted a significant decrease in control (+) compared to control (-ve). Hyperglycemic and fed on sugar beet, sweet potato, and potato leaves and stems 5% kidney % revealed pronounced increase compared to control (+ve) rats which were 0.68±0.01, 0.57±0.02, 0.63±0.01% respectively. On the other hand, in hyperglycemic rats fed on taro and carrot leaves and stems 5% reflected significantly slight increase

compared to control (+ve) which were 0.70±0.05, 0.71±0.02, and 0.69±0.02 respectively.

1.2.5. The relative lungs weight:

The obtained data of table (2) indicated that in control (ve) normal rats lungs % was 0.76±0.08% while in control (+ve) diabetic rats without treatment it was 0.84±0.02%. It could be observed that there was a significant increase in control (+) compared to control (-ve). As regards lungs %. hyperglycemic rats fed on carrot, sugar beet, and sweet potato leaves and stems showed significant decrease of lungs % compared to control (-ve) & control (-ve) groups which were 0.74±0.07, 0.73±0.04, and 0.65±0.03% respectively. On the other hand, diabetic rats fed on taro and potato leaves and stems 5% revealed non-significant differences compared to control (-ve) group values were 0.76±0.07, 0.77±0.08, and 0.76±0.08% respectively. The data of table (2) went parallel to that of **Ahmed, Reham (2007).** It should be noted that hypercholesterolemia caused atrophy of liver, heart and lungs, while hypercholesterolemia resulted in inflammation

Table (2): Effect of taro, carrot, sugar beet, Sweet potato, and potato's leaves and stem on relative organs weight in hyperglycemic rats.

Parameters / Groups	Liver (%)	Heart (%)	Spleen (%)	Kidney (%)	Lungs (%)
Control (-ve)	3.68±0.13^{c}	0.35±0.03^{d}	0.44±0.05^{b}	0.73±0.06^{a}	0.76±0.08^{b}
Control (+ve)	4.15±0.14^{a}	0.42±0.02^{a}	0.48±0.02^{a}	0.69±0.02^{c}	0.84±0.02^{a}
Taro leaves and stem 5%	3.40±0.08^{d}	0.39±0.03^{b}	0.36±0.04^{c}	0.70±0.05^{b}	0.76±0.07^{b}
Carrot leaves and stem5%	3.19±0.06^{f}	0.38±0.02^{b}	0.35±0.02^{c}	0.71±0.02^{b}	0.74±0.07^{c}
Sugar beet leaves and stem5%	3.99±0.19^{b}	0.39±0.04^{b}	0.42±0.01^{b}	0.68±0.01^{c}	0.73±0.04^{c}
Sweet potato leaves and stem 5%	3.24±0.21^{e}	0.37±0.04^{c}	0.4±0.04^{b}	0.57±0.02^{e}	0.65±0.03^{d}
Potato leaves and stem 5%	3.73±0.19^{c}	0.37±0.02^{c}	0.38±0.03^{c}	0.63±0.01^{d}	0.77±0.08^{b}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1.3. Effect on liver enzymes of serum:

Data listed in table (3) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on liver of serum enzymes (GOT, GPT, and ALP) of hyperglycemic rats.

1.3.1. Serum GOT:

The obtained data show that in control (-ve) normal rats GOT was 48.75±1.25(U/L), while in the control (+ve) diabetic rats without treatment it was 67.25±0.60 (U/L). These results denoted a significant increase in control (+) compared to control (-ve) rats. Hyperglycemic rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stems 5% recorded significant decrease compared to control (+ve) group which were 25.75±1.62, 30.25±1.49, 57.75±1.45, 35.75±1.13, and 27.5±1.67 (U/L) respectively.

1.3.2. Serum GPT:

It could be observed that in control (-ve) normal rats GPT was 17.25±0.63 (U/L), while in the control (+ve) hyperglycemic rats without treatment was 23.5±0.11 (U/L). These results indicated that there was a significant increase in control (+) compared to control (-ve) rats. Hyperglycemic rats fed on taro, carrot, sugar beet, sweet potato, and potato leaves and stems 5% recorded significant decreases compared to control (+ve) group, values were 8.25±0.32, 7.75±0.63, 17.5±0.29, 12.75±0.65, 5.75±0.18 (U/L) respectively.

2. 3. 3. Serum ALP:

The results of table (3)) showed that in control (-ve) normal rats ALP was 260.5±17.06 (U/L), while in control (+ve) diabetic rats without treatment was 380.0±28.57 (U/L). These results revealed that there was a significant in-crease in control (+) compared to control (-ve) group. Diabetic rats fed on taro, carrot, sweet potato, and potato leaves and stems 5% indicate significant decreases compared to control (+ve) group, values were 360.0±27.39, 330.0±28.57, 373.3±49.39, and 295.0±13.23 (U/L). On the other hand in diabetic rat and fed on sugar beet leaves and stems 5% there was non-significant changes compared to control (+ve) group showing values of 380.0±49.49, 380.0±28.57 (U/L) respectively. The changes of liver enzymes in serum were in line with that reported by **Lee, et al (2003).**

Table (3): Effect of taro, carrot, sugar beet, sweet potato, and potato's leaves and stem on liver enzymes (GOT, GPT, and ALP) of hyperglycemic rats.

Parameters / Groups	GOT (U/L)	GPT (U/L)	ALP (U/L)
Control (-ve)	48.75±1.25^{c}	17.25±0.63^{b}	260.5±17.06^{f}
Control (+ve)	67.25±0.60^{a}	23.5±0.11^{a}	380.0±28.57^{a}
Taro leaves and stem 5%	25.75±1.62^{e}	8.25±0.32^{d}	360.0±27.39^{c}
Carrot leaves and stem 5%	30.25±1.49^{e}	7.75±0.63^{d}	330.0±28.57^{d}
Sugar beet leaves and stem 5%	57.75±1.45^{b}	17.5±0.29^{b}	380.0±49.49^{a}
Sweet potato leaves and stem 5%	35.75±1.13^{d}	12.75±0.65^{c}	373.3±49.39^{b}
Potato leaves and stem 5%	27.5±1.67^{e}	5.75±0.18^{e}	295.0±13.23^{e}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1.4. Effect on (T. protein, Albumin, Globulin, and Alb/Glob):

Data present in table (4) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on (T. protein, Albumin, Globulin, and Alb/Glob) of hyperglycemic rats.

1.4.1. T. protein:

The obtained data revealed that in control (-ve) normal rats T. protein was 10.9±0.56 (g/dl), while in the control (+ve) diabetic rats without treatment it was 9.75±0.37 (g/dl). These results indicated that there was a significant decrease in control (+) compared to control (-ve) values. Diabetic rats fed on taro, carrot, sugar beet, and potato leaves and stems 5% observed significant increase of T. protein compared to control (+ve) group, which were 11.25±0.99, 10.73±0.32, 10.7±0.55, and 10.65±0.60 (g/dl) respectively. On the other hand in diabetic rat and fed on sweet potato leaves and stems 5% diet showed significant decrease T. protein compared to control (+ve) group, which were 7.93±0.78, and 9.75±0.37 (g/dl) respectively.

1.4.2. Albumin:

Data presented in table (4) indicated that in control (-ve) normal rats albumin was 3.53±0.41(g /dl), while in the control (+ve) diabetic rats without treatment it was 2.35±0.19 (g/dl). This revealed significant decrease in control (+ve) albumin compared to control (-ve) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% revealed significant increase compared to control (+ve) group, which were 3.8±0.16, 4.53±0.29, 4.33±0.48, 4.1±0.54, and 4.93±0.35 (g/dl) respectively.

1.4.3. Globulin:

Data present in table (4) showed that in control (-ve) normal rats globulin was 5.73±0.71 (g/dl), while in the control (+ve) diabetic rats without treatment it was 7.65±0.19 (g/dl). These data showed that there was a significant increase in control (+) compared to control (-ve) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet revealed significant decrease compared to control (+ve) rats, which were 5.88±0.21, 6.2±0.11, 6.38±0.63, 3.83±0.42, and 5.23±0.55 (g/dl) respectively. The best results were for diabetic rats fed on sweet potato leaves and stems 5% diet as globulin was 3.83±0.42 (g/dl), while in control (-ve) it was 5.73±0.71 (g/dl) respectively.

1.4.4. ALB /Glob ratio:

Data presented in table (4) indicated that in control (-ve) normal rats Alb/Glob was 0.68±0.18 (g/dl), while in the control (+ve) diabetic rats without treatment it was 0.31±0.02 (g/dl). These results reflected a significant decrease in control (+ve) compared to control (-ve) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant increases compared to control (+ve) group, which were 0.71±0.12, 0.73±0.05, 0.71±0.12, 1.04±0.05, and 1.00± 0.20 (g/dl) respectively. The T. protein, albumin, globulin & Alb/Glob changes given in table (21) and Fig. (12) a & b concurred with that reported by **Abidin, (2004) & Abd El-Aziz, and Om-Kalsom (2005**)

Table (4): Effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on (T. protein, Albumin, globulin, and Alb/Glob) of hyperglycemic rats.

Parameters / Groups	T. protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Alb/Glob
Control (-ve)	10.9±0.56^{b}	3.53±0.41^{d}	5.73±0.71^{c}	0.68±0.18^{c}
Control (+ve)	9.75±0.37^{d}	2.35±0.19^{e}	7.65±0.19^{a}	0.31±0.02^{d}
Taro leaves and stem 5%	11.25±0.99^{a}	3.8±0.16^{c}	5.88±0.21^{c}	0.71±0.12^{b}
Carrot leaves and stem 5%	10.73±0.32^{b}	4.53±0.29^{b}	6.2±0.11^{b}	0.73±0.05^{b}
Sugar beet leaves and stem 5%	10.7±0.55^{b}	4.33±0.48^{b}	6.38±0.63^{b}	0.71±0.12^{b}
Sweet potato's leaves and stem 5%	7.93±0.78^{c}	4.1±0.54^{c}	3.83±0.42^{e}	1.04±0.05^{a}
Potato's leaves and stem 5%	10.65±0.60^{b}	4.93±0.35^{a}	5.23±0.55^{d}	1.00±0.20^{a}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1.5. Effect on kidney function:

Data presented in table (5) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on kidney function (urea, creatinine and U. acid) of hyperglycemic rats**.**

1.5.1. Urea:

The obtained data in table (5) indicated that in control (-ve) normal rats urea was 25.58±1.14 (mg/dl). While in the control (+ve) diabetic rats without treatment it was 47.30±0.89 (mg/dl). These results showed that there was a significant increase of urea in control (+) compared to control (-ve) rats serum. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant decreases of urea compared to control (+ve) rats, which were 30.60±1.21, 34.50±0.87, 30.40±0.61, 34.66±0.54, 34.26±0.92 (mg /dl) respectively.

1.5.2. Creatinine:

These results of table (5) revealed that in control (-ve) normal rats creatinine was 0.63±0.05 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 0.90±0.02 (mg/dl). Such data reflected a significant increase in control (+) compared to control (-ve) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant decreases compared to control (+ve) rats, which were 0.68±0.05, 0.89±0.15, 0.75±0.07, 0.83±0.06, and 0.88±0.09 (mg/dl) respectively.

1.5.3. U. acid:

It could be observed that in control (-ve) normal rats U. acid was 1.4±0.12 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 2.95±0.33 (mg/dl). These results reflected a significant increase in control (+) compared to control (-ve) rats. Diabetic rats fed on taro, carrot sugar beet, sweet potato and potato leaves and stems 5% diet denoted significant decreases compared to control (+ve) rats, which were 1.04±0.02, 1.3±0.13, 2.00±0.13, 1.84±0.12, and 1.92±0.14 (mg/dl) respectively. The best result revealed in case of taro leaves and stems 5% diet which was 1.04±0.02 (mg/dl). The changes of urea, creatinine and uric acid changes went parallel to that reported by **Abd El-Aziz, and Om-Kalsom (2005**) working on broccoli for lowering serum glucose and total cholesterol.

Table (5): Effect of taro, carrot, sugar beet, sweet potato, and potato's leaves and stem on kidney function (Urea, creatinine, and U. acid) in hyperglycemic rats.

Parameters / Groups	Urea (mg/dl)	Creatinine (mg/dl)	U. Acid (mg/dl)
Control (-ve)	25.58±1.14^{d}	0.63±0.05^{d}	1.4±0.12^{d}
Control (+ve)	47.30±0.89^{a}	0.90±0.02^{a}	2.95±0.33^{a}
Taro leaves and stem 5%	30.60±1.21^{c}	0.68±0.05^{d}	1.04±0.02^{e}
Carrot leaves and stem 5%	34.50±0.87^{b}	0.89±0.15^{b}	1.3±0.13^{d}
Sugar beet leaves and stem 5%	30.40±0.61^{c}	0.75±0.07^{c}	2.00±0.13^{b}
Sweet potato leaves and stem 5%	34.66±0.54^{b}	0.83±0.06^{b}	1.84±0.12^{c}
Potato leaves and stem 5%	34.26±0.92^{b}	0.88±0.09^{b}	1.92±0.14^{c}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1. 6. Effect on some lipids profile:

Data presented in table (6) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on some lipids profiles (T. cholesterol, T. lipids, triglyceride, and phospholipids) of hyperglycemic rats.

1. 6. 1. Total cholesterol (T. C):

The data of table (6) revealed that in control (-) normal rats T. cholesterol was 117.78±3.66 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 160.00±3.0 (mg/dl). These data reflected a significant increase in control (+) compared to control (-ve) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant decreases compared to control (+) rats, which were 120.5±2. 92, 118.0±1.08, 150.5±2.10, 106.75±2.33, and 118.25±1.19 (mg/dl) respectively. The best result denoted in diabetic rats fed on sweet potato which was 106.75±2.33 (mg/dl).

1.6.2. Serum T. Lipids (T. L):

The obtained data presented in table (6) showed that in control (-) normal rats T. Lipid was 440.0±5.36 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 688.0±4.40 (mg/dl). This result reflected a significant increase in control (+) compared to control (-ve) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant decreases compared to control (+ve) rats, which were 482.0±3.68, 515.0±2.38, 477.0±1.58, 433.25±1.41, and 414.0±1.83 (mg/dl) respectively.

1.6.3. Serum triglyceride (T. G):

Result of table (6) indicated that in control (-) normal rats triglycerides level was 74.25±1.11 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 205.5±5.70 (mg/dl). Such result reflected a significant increase in control (+) rats compared to control (-ve) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet revealed significant decreases compared to control (+ve) group which were 95.25±2.50, 101.75±3.82, 117.25±1.11, 106.75±1.65, and 101.25±1.65 (mg/dl) respectively.

1.6.4. Serum phospholipids:

Data present in table (6) revealed that in control (-) normal rats phospholipids was 248.25±3.23 (mg/dl), while in the control (+ve) diabetic rats without treatment it was 314.75±4.75 (mg/dl). This result revealed significant increase in control (+) rats compared to control (-ve) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet showed significant decreases compared to control (+ve) group which were 266.25±3.98, 295.0±3.49, 209.25±1.32, 218.25±1.68, 194.25±1.32 (mg/dl) respectively.

Table (6): Effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on lipids profiles (T. cholesterol, T. lipids, triglyceride, and phospholipids) of hyperglycemic rats.

Parameters / Groups	T. Cholesterol (mg/dl)	T. Lipids (mg/dl)	Triglyceride (mg/dl)	Phospholipids (mg/dl)
Control (-ve)	117.78±3.66^{d}	440.0±5.36^{d}	74.25±1.11^{f}	248.25±3.23^{d}
Control (+ve)	160.00±3.0^{a}	688.0±4.40^{a}	205.5±5.70^{a}	314.75±4.75^{a}
Taro leaves and stem 5%	120.5±2.92^{c}	482.0±3.68^{c}	95.25±2.50^{e}	266.25±3.98^{c}
Carrot leaves and stem 5%	118.25±1.08^{d}	515.0±2.38^{b}	101.75±3.82^{d}	295.0±3.49^{b}
Sugar beet leaves and stem 5%	150.5±2.10^{b}	477.0±1.58^{c}	117.25±1.11^{b}	209.25±1.32^{e}
Sweet potato leaves and stem 5%	106.75±2.33^{e}	433.25±1.41^{d}	106.75±1.65^{c}	218.25±1.68^{e}
Potato leaves and stem 5%	118.5±1.19^{d}	414.0±1.83^{e}	101.25±1.65^{d}	194.25±1.32^{f}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

1.7. Effect on cholesterol functions:

Data listed in table (7) show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on cholesterol function (HDL, LDL, VLDL, and LDL+LDL/HDL) of hyperglycemic rats.

1.7.1. Serum HDL:

The obtained data table (7) indicated that in control (-ve) normal rats HDL was 64.5±1.97 (mg/dl), while in the control (+) diabetic rats without treatment it was 50.5±1.12 (mg/dl). These results reflected significant decrease in control (+) rats compared to control (-) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet reflected significant increases compared to control (+) rat which were 60.0±1.91, 81.0±1.71, 78.5±1.19, 67.75±1.65, and 71.25±1.65 (mg/dl) respectively.

1.7.2. Serum LDL:

Data observed in Table (7) indicated that in control (-) normal rats LDL was 38.43±2.76 (mg/dl), while in the control (+) diabetic rats without treatment it was 68.4±2.58 (mg/dl). These results reflected

significant increase in control (+) rats compared to control (-). Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet revealed significant decreases compared to control (+) group which were 41.45±1.98, 16.9±1.21, 48.55±1.29, 17.65±2.43, and 27.00±1.93 (mg /dl) respectively.

1.7.3. Serum VLDL:

The obtained data indicated that in control (-ve) normal rats VLDL was 14.85±0.22 (mg/dl), while in the control (+) diabetic rats without treatment it was 41.1±0.14 (mg /dl). This result showed a significant increase in control (+) rats compared to control (-). Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% diet revealed significant decreases compared to control (+) group which were 19.05±0.50, 20.35±0.77, 23.45±0.22, 21.35±0.74, and 20.25±0.33 (mg/dl) respectively.

1.7.4. Atherogenic index (A. I) [VLDL+LDL/ HDL]:

The obtained data Table (7) indicated that in control (-ve) normal rats VLDL+LDL/HDL was 0.83±0.02, while in the control (+) diabetic rats without treatment it was 2.17±0.47, These data reflected a significant increase in control (+) rats compared to control (-) group. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% denoted significant decreases compared to control (+) group which were 1.03±0.18, 0.47±0.09, 0.92±0.04, 0.58±0.07, & 0.66±0.05 respectively. The changes of lipid functions (Tables 23 & 24 and Figs. 14 & 15 "a, b") concurred with the results of **Goldberg, *et al* (2001)** working on the effect of marine algae on lipids profile of hyperglycemic rats.

1. 8. Effect on serum glucose:

Data listed in table (8) Show the effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on serum glucose of hyperglycemic rat.

The obtained data showed that in control (-) normal rats serum glucose was 117.75±2.72 (mg/dl), while in the control (+) diabetic rats without treatment it was 249.50±2.20 (mg /dl). Hence there was a significant increase in control (+) compared to control (-) rats. Diabetic rats fed on taro, carrot, sugar beet, sweet potato and potato leaves and stems 5% denoted significant decreases compared to control (+) group which were 142.25±2.175, 180.00±2.08, 152.00±2.04, 140.25±1.25, and 126.50±1.76 (mg/dl) respectively. Potato leaves & stem diet seems to be the best treatment. The results of serum glucose changes were in line with that found by **Ahmed, Reham (2007)** working on feeding certain plants to hyperglycemic rats.

Table (7): Effect of taro, carrot, sugar beet, sweet potato, and potato leaves and stem on cholesterol function (HDL, LDL, VLDL, and VLDL + LDL / HDL) of hyperglycemic rats.

Parameters / Groups	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	(VLDL+LDL)/HDL ratio
Control (-ve)	64.5±1.97^{b}	38.43±2.76^{c}	14.85±0.22^{e}	0.83±0.02^{c}
Control (+ve)	50.5±1.12^{d}	68.4±2.58^{a}	41.1±0.14^{a}	2.17±0.47^{a}
Taro leaves and stem 5%	60.0±1.91^{c}	41.45±1.98^{c}	19.05±0.50^{d}	1.03±0.18^{b}
Carrot leaves and stem 5%	81.0±1.71^{a}	16.9±1.21^{e}	20.35±0.77^{c}	0.47±0.09^{e}
Sugar beet leaves and stem 5%)	78.5±1.19^{a}	48.55±1.29^{b}	23.45±0.22^{b}	0.92±0.04^{c}
Sweet potato leaves and stem 5%	67.75±1.65^{b}	17.65±2.43^{e}	21.35±0.74^{b}	0.58±0.07^{d}
Potato leaves and stem 5%	71.25±1.65^{b}	27.00±1.93^{d}	20.25±0.33^{c}	0.66±0.05^{d}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

Table (8): **Effect of taro, carrot, sugar beet, sweet potato, and Potato leaves and stem on glucose of hyperglycemic rats.**

Parameter / Groups	Glucose (mg/dl)
Control (-ve)	117.75±2.72^{f}
Control (+ve)	249.50±2.20^{a}
Taro leaves and stem 5%	142.25±2.175^{d}
Carrot leaves and stem 5%	180.00±2.08^{b}
Sugar beet leaves and stem 5%	152.00±2.04^{c}
Sweet potato leaves and stem 5%	140.25±1.25^{d}
Potato leaves and stem 5%	126.50±1.76^{e}

- Values are expressed as mean ± SD.
- Significant at P> 0.05.
- Values which don't share the same letter in each column are significantly different.

Recommendations

1. It is suggested to use vegetable greens of tuberous plants, namely that of taro, carrot, sugar beet, sweet potato and potato for h hyperglycemic patients.
2. Vegetable greens of tuberous plants, especially that of potato, sweet potato and taro may be used for remedy of liver disorders.
3. Taro followed by sugar beet leaves and stems may be suggested for amelioration of renal dysfunction.
4. Vegetable greens of tuberous plants, in particular that of carrot and potatoes may be suggested for lowering LDL and atherogenig index levels.
5. Studies may be suggested to evaluate the efficacy and advantage of using vegetable greens of tuberous plants as extracts versus dried powder.

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