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BIOCHEMICAL AND HISTOPATHOLOGICAL EVALUATION OF RADISH MICROGREEN AND CLOVER ETIOLATED SPROUTS AGAINST DIABETIC MELLITUS RATS

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ABSTRACT
In this work, radish microgreen and clover etiolated sprouts were added of semi-modified diet (10%) for 6 weeks in streptozotocin-induced diabetic rats (60 mg/kg) to investigate their effect on blood sugar, liver and kidneys function and organ histopathology. The results revealed a significant elevation in blood sugar, urea, AST, ALT activities, creatinine and uric acid in rat than the control group animal. Also, the increased and decreased values by STZ-diabetic animal were improved by 10% semi-modified diet. Histopathological analysis of various organ tissues resulted in a significant alteration which is attributable to the STZ injection, while radish microgreen and clover etiolated sprouts semi-modified diet showed amelioration in STZ influences on organ. From the data, it may be concluded that Radish microgreen and clover etiolated sprouts has the potential to alleviate hyperglycemia and possess antioxidant effects in cases of diabetic state or for prevention of this disease.

KEYWORDS: Radish Microgreen; sprout; diabetes; Histopathological analysis.

1. INTRODUCTION

Interest in sprouts and microgreen as a human food has a long history. Ancient Egyptian and Chinese thousands of years ago. Consumed sprouts and microgreen as a healthy food, especially for healing and rejuvenation (Abdallah. 2008). Microgreen are seedling grown to fully opened cotyledons or to1st true leaf stage. Harvested at 7-20 days from seed sowing, depending on plant species and they contain higher levels of vitamin, minerals and antioxidants than plant fruits or seeds (Xiao *et al*. 2012). Sprouting is the process widely used to improve the nutritional value of forming sprouts. The microgreen and sprouts are in the group of “functional foods” which have health promoting or disease preventing properties and are one of the most complete and nutritious foods in recent times (Brazaityte *et al*. 2015).

Searching for protection against diabetes and other diseases by the means of foods is very attractive, especially when taken into consideration that, very little progress was achieved by the medicine (Farlay *et al*. 2004). In folk medicine the seeds of clover were used as antidiabetic agent and also, radish have been used as medicinal food for a variety of elements (Shukla *et al*., 2011). Abdallah (2008) determined 8 days of growth to be the optimum period for radish microgreen, which was grown in light and 3 days was appropriate for clover etiolated sprouts. However, despite many reports on the beneficial effects of natural products on diabetes mellitus, little information is available about the anti-diabetic activity of seed sprouts and no microgreens research available in Egypt about the anti-diabetic activity of seed sprouts. Diabetes mellitus is a metabolic disease characterized by hyperglycemia, hyperinsulinemia, hyper aminoacidemia and hyperlipidemia, it leads to inhibition in both insulin action, and insulin secretion (Altan. 2003). Nitric oxide is liberated by STZ induction diabetes which reduced aconitase activity and participates in DNA damage. Also, B cells undergo the destruction by necrosis.

Depending on species and sprouting conditions seed sprouts and microgreen have a high antioxidant vitamin (A and C) compared to un germinated seeds (Abdallah *et al*. 2009). Concerning semi-modified diet on experimental animals, researchers reported that STZ-diabetes increased blood glucose levels (Akbarzadeh *et al*. 2007). And stimulated the enzymes activity of liver function (AST and ALT) (Al-Logmanli and Zari. 2009). Also, STZ-diabetes increased serum urea, uric acid and creatinine content compared to normal control group (Al-Logmanli and Zari. 2009). However, the addition of functional foods of seed sprouts and microgreen as semi-modified to diabetic experimental animals resulted decrease in blood glucose and improved the liver and kidney function prameters induced by STZ- diabetic as reported by (Sdeek. 2011; Al-Logmanli Zari. 2009).

Concerning the histopathological study of STZ- diabetic rat, Kulkarni *et al* (2012) reported that, the mean number of pancreatic â -cell in STZ- diabetic rat significantly decreased as compared with normal rats. Whereas Trigonella foenumgraecum seed ethyl alcohol (70%) extract treated rats significantly reversed STZ- induced depletion of pancreatic â – cell mass, indicated â–cell protection or regeneration potential of seed extract. Aqueous extract Raphanus sativus treated rats decreased necrotic cells of islets and lymphocyte infiltration of STZ – diabetic pancreas and also shows normal islet as compared with diabetic positive control (Dehghani *et al*. 2011).

Haque *et al* (2014) found that the livers of the Raphanus sativus hot water extract – fed hypercholesterolemic animals exhibited lesser fatty droplets and reduced inflammatory cells. They concluded that histological data provided strong evidence of the positive influence of the radish extract on the cellular morphology. Zafar *et al* (2009) found that, histopathological examination of liver in diabetic rat showed accumulation of lipid droplets, lymphocytic, increased fibrous content, dilatation and congestion of portal vessels and proliferation of bile ducts. Khaki *et al* (2009) reported that, histopathological examination revealed that diabetes increased apoptosis index in liver tissue while the treatment of diabetic rats with quercetin significantly improved the liver cells damages by decreasing number of apoptosis liver cells. Therefore, suggested increased use of herbal medicine, fruits, vegetables, onion, tea and black grape which are full of flavonoids and quercetin can decrease side effects of diabetes mellitus on liver tissue (Khaki *et al*. 2009).

Kidneys histopathological studies observed enlargement of lining cells of tubules, fatty infiltration, large area of hemorrhage and lymphocyte infiltration in the diabetic rats and treatment with umbelliferon (a natural antioxidant in some fruits) reversed these changes to near normalcy and 10% dimethyl sulphoxide extract from flower head of Trifolium alexandrium (Egyptian clover) improved histological and biochemical alterations of the kidneys noticed in STZ- diabetic rats. The effects explained by the presence of a high content of flavonoids which act synergistically as antioxidants (AL-Rawi. 2007[b]). Ramzy *et al* (2014) reported that, induction of diabetes caused distraction of histological normal testicular structure and (the non – selective â – adrenoceptor blocker) carvedilol confers testicular protection against diabetes – induced damage through antioxidant and anti – apoptosis mechanisms. The objective of the present work studied the influences of sprouting on vitamins, phenol and flavonoids of radish microgreen and clover etiolated sprouts and also to investigate the influence of radish microgreen and clover etiolated sprouts as semi-modified diets on blood sugar, liver and kidney function and histopathological effects on rat organs metabolism in normal and STZ induced diabetic rats.

2. MATERIAL AND METHODS

2.1. Seed Sprouts of Radish and Clover

Seeds of radish (Raphanus sativus) and clover (Trifolium alexandrium) were obtained from private farm in Kalubia Governorate and from ARC, forage department respectively. Radish is a member of Cruciferous/Brassica family while clover is a member of the /Fabaceae family. radish microgreen was developed in open field and harvested at fully expanded green cotyledons stage which was 8 days from seed sowing While clover etiolated sprouts were producing using glass jar method. In the jar methods clover seeds and soaking tap water was placed in a 07. capacity glass jar (household version) which was then covered with cheese cloth secured by a rubber band. The jar was stored in dark for 12hr. to allow seeds to soak at room temperature. After which soaking water was discarded and the seeds were rinsed with water in the jar (approximately 1.0 min.). The rinse water was discarded; the jar was inverted at a 45^{o} angle and stored at room temperature in dark 12hr. The rinse-store procedure was repeated 6 times until 72hr. (3days) cumulative time had been completed (harvest time). The harvested sprouts were collected at three days from seed soaking, washed and hulled before dried as reported by Abdallah (2008). Samples of harvested radish and clover sprouts and ungerminated dry seeds were oven dried at 60˚C for 48 h and ground in laboratory Wiley mill to pass through a 40-mesh sieve.

2.2. Vitamin analysis

Total ascorbic acid (Vitamin C) was determine according to the methods of Bajaj and Kaur (1981); and vitamin A (â-carotene) was determined according to the methods of Leth and Jacobsen (1993).

2.3. Determination of total phenols, flavonoids and sugars profile

Determination of total phenols according to the method described by Danial and George (1972) and total flavonoids according to Chang *et al* (2002) method. Total soluble sugars; reducing and non-reducing sugars were determined according to the method described by Dubois *et al* (1956).

2.4. Animals and diets

Male Wister rats {obtained from Organization of Biological Products and Vaccines} were individually housed in cages in animal experimental room. They were allowed free access to water and standard diet for 7 days for acclimation, half of the rats were injected intraperitoneally with STZ (60 mg/ kg body weight) dissolved in 0.09 M citrate buffer (pH 4.5) to induce a diabetic status according to Tahany Aly (2015). One week after the injection, hyperglycemia was confirmed with a blood glucose test. Only rats with at least blood glucose values of 350 mg/dl or above were used in this study. After the acclimatization, the normal and diabetic rats were each divided into three group(n=6/group) and fed diets containing 0.0 and 10% of radish microgreen or 10% of clover etiolated sprout at the expense of cornstarch ad libitum for 6 weeks. After that, rat organs the (pancrease; liver; kidney and tests) were collected from anesthetized rats that had been deprived of food for overnight.

2.5. Histopathological examination of rat organs

Sample of rat pancrease, liver; kidney and tests were immersed in 10% formalin. until fixed in Bouins fixative embedded in paraffin wax. Detailed microscopic examination for each organs sample section (5µm) was carried out on all organs of each group according to Carleton *et al* (1967).

2.6. Statistical analysis

The obtained data were statically analyzed using the method of Snedecor and Cochran (1980) and LSD (0.05) was used to compare the significant different between mean of treatments.

3. RESULTS AND DISCUSSIONS

3.1. Effect of sprouting on vitamin A and C

Table (1) shows the amounts of vitamins A and C of radish microgreen (8 days old) and etiolated clover sprouts (3 days old) as compared with dry seeds. Vitamin C, quantified as total ascorbic acid content was low in seeds (8.83 mg/ 100 g in clover and 18.9 mg/ 100 g in radish). These results agree with Abdallah et al (2009) on green sunflower sprout. Sprouting has been suggested as an efficient, natural and low-cost method for supplying vitamin C in the diet, sprouting of radish and clover seems to be a good process to enhance their antioxidant capacity.

Vitamin A content expressed as its precursor â- carotene. Table (1) showed higher amount of â- carotene in radish microgreen sprouts than clover etiolated sprouts. However, sprouting caused an increase in â-carotene in radish microgreen (9.2 folds) higher than seeds but there was loss in the content of it in clover etiolated sprouts (25% lower related to seeds). The obtained results indicated that provitamin A content increased sharply in radish microgreen, which has photosynthesis process but decreased in clover etiolated sprout one which has not chlorophyll. Similar results of provitamin A in radish microgreen was obtained by Abdallah *et al* (2009) in green sunflower sprouts.

3.2. Effect of sprouting on total phenol, total flavonoids and sugars profile

Table (1) shows the effect of sprouting on radish microgreen and clover etiolated sprout content of sugars profile, total phenols and total flavonoids. Radish and clover contained higher total phenols and total flavonoids than their seeds, but lower total soluble and non-soluble sugar percentage in clover etiolated sprout of dry weight basis compared with clover seeds. In contrast green radish sprout contained higher sugars profile than those of radish seeds. These results agree with those reported that Japanese radish sprout had higher flavonoids (Takaya *et al*. 2003). The present results are confirmed by the suggestion that chlorophyll in radish microgreen significantly increased the three kinds of sugar profile by photosynthesis but not in clover etiolated sprout (without chlorophyll and photosynthesis). The significant increases in total phenols and flavonoids may be due to that sprouting processes synthesized these compounds with vitamin C as good antioxidant agents against the environmental pollution and anti-xenobiotic induction may affect the sprout growth.

3.3. Effect of radish microgreen and clover etiolated sprouts semi-modified diets on blood glucose

Concerning blood glucose levels measured at zero time (one week after STZ injection) and finally at the end of the experiment (6 weeks after feed treatment). Data in Table (2) showed hyperglycemia with STZ-diabetic control and their treated groups by microgreen and sprout (groups 2,4 and 6) one week after STZ injection (zero week). The hyperglycemia with STZ diabetic control was observed during the whole 6 weeks (studied period) with increment which amounted 430 and 544 mg/dl at the starting and last week of the experimental period respectively. The significant increase in blood glucose level in STZ-diabetic agreement with Akbarzadeh *et al* (2007). Feeding diabetic rats on radish microgreen and clover etiolated sprouts semi-modified diets for 6 weeks studied period decreased the hyperglycemia to around but more than normal state compared with normal treatments. The decrease in blood glucose levels recorded about 172 and 178mg/dl in STZ induced diabetic rats treated with the diets containing the radish microgreen and clover etiolated sprouts respectively. The diabetic control showed 544 mg/dl at the same time. (Table 2).

The mechanism of these radish microgreen and clover etiolated sprouts decreased blood glucose levels. Hyperglycemia increase free radicals' generation by glucose auto - oxidation and the elevation of free radicals may be due to liver cell damage. The increase in oxygen free radicals in diabetes condition could be due to the increment in blood glucose content and due to the influences of the streptozotocin diabetogenic agent (Szkudelski, 2001). Previous studies demonstrated that radish sprouts and radish extracts and their active constituent have attenuated free radical scavenging and antioxidant activity (Wang *et al*. 2010 and Zhou *et al*. 2013).

These studies suggested that the mechanism of activity by radish microgreen and clover etiolated sprouts may be due to antioxidants that aid to recover from impaired glucose metabolism. The STZ-diabetes may first increase the entrance glucose rate into the blood from the liver (stimulated hepatic glycogenolysis or gluconeogenesis) or to reduce removal rate of glucose from blood to tissues (inhibiting storage and utilization). STZ acts directly promptly and specifically on the pancreatic â-cells (Abed *et al*. 2015). However, the radish microgreen and clover etiolated sprouts semi-modified diets were effective as hypoglycemic agents where glucose levels reduced at the end of experimental period by about 90%.

3.4. Effect of radish microgreen and clover etiolated sprout semi-modified diets on liver and kidney function

In diabetic control the AST and ALT activities stimulated by 31% and 28% respectively, at that of normal control (Table 2). Feeding diabetic rats on radish microgreen and clover etiolated sprout semi-modified diets for 6 weeks experimental period caused readjustment in the activity of these enzymes by 15% and 20% respectively, for AST and 35% and 34% respectively, for ALT. STZ-induced diabetic rats increased bilirubin levels by about 31% compared with control. The feeding diabetic rats with radish microgreen and clover etiolated sprout for 6 weeks study period caused impartments in the bilirubin level to approximately around normal level.

Increasing AST and ALT activities in STZ-induced diabetic rats relative to control also diabetes may be induced due to liver dysfunction. Therefore, stimulation in the activities of AST and ALT in blood fraction (serum) may be mainly due to the leakage of these enzymes from the liver cytosol into the blood stream (Navarro *et al*. 1993) which gives an indication on the hepatotoxic effect by STZ. However, treated the diabetic animal with radish microgreen and clover etiolated sprout caused improvements enzymes activity compared to diabetic group and consequently may alleviate damage caused by STZ-to liver. Explanation for the differential effects of clover etiolated sprout and radish microgreen on the AST and ALT activities in blood is that these treatments may inhibit damage induced by streptozotocin to liver. Feeding on radish microgreen and clover etiolated sprout –semi-modified diets for diabetic rats was characterized by improvement blood glucose which was paralleled with the readjustment of AST and ALT activists, which inhibited the gluconeogenesis (conversion of amino acid into glucose).

Results of kidneys function of the different experimental groups are shown in (Table 2) serum urea levels in STZ-diabetic rats (diabetic control) was higher (about 35%) compared with normal control rats. Addition of radish microgreen and clover etiolated sprout to the diets of diabetic groups (4 and 6) readjusted the level of serum elevated urea as compared to diabetic control and the decrease reach to the normal range of normal groups (3 and 5 and normal control). Serum creatinine and uric acid levels in STZ-diabetic rats was lower compared with normal group rats (Table 2). The decrement was more pronounced in uric acid than creatinine with percentage of 30% and 15% respectively compared with normal control. Similar effects on increasing blood urea in STZ- induced diabetic was recorded previously (Al-logmanli and Zari. 2009) and in decreasing uric acid and creatinine was recorded also previously (Al-logmanli and Zari. 2009). On the contrary, creatinine and uric acid were reduced in diabetic animals. Possible effects in tubular reabsorption and probably increased excretion of nitrogen in urea may explain such decrement in blood uric acid and creatinine. Previous changes in serum urea, uric acid and creatinine levels strongly suggested impairment function of kidneys in diabetes. The treatment with radish microgreen and clover etiolated sprout improved the total protein level to near normal levels, but, the level of uric acid and creatinine were more than normal health rats. The main effects of radish microgreen and clover etiolated sprout are presumably due to its ability to increase insulin secretion.

Effect of radish microgreen and clover etiolated sprouts semi-modified diets on histopathological studies.

3.5. Histopathological examination of rat pancreas

Histopathological examinations of the rat pancreas's section under the present study are presented in Fig. 1(A). The section of the pancreas of normal rats showed normal appearance of Langerhans and acinar cells Fig. 1(A.a) the rats from diabetic control group showed necrosis of cells of islets of Langerhans with pyknosis of the nucleus of some cells. Also, some section showed complete lysis of epithelial lining of islets of Langerhans with infiltration of monocular cells mainly lymphocytes and macrophages Fig.1 (A.b). Similar results for extra pancreatic cytotoxicity in diabetic rats than normal rats were obtained by and Kulkarni *et al* (2012). The rats from STZ- induced diabetic fed a diet supplemented with sprouts (radish microgreen diabetic group and clover etiolated sprout diabetic group), its pancreas section appeared normal Fig. 1 A. (c and d). These finding are confirmed with results of blood glucose that STZ-diabetic rats showed increasing in blood glucose relative to necrosis of langerhance islets cells. Under the Radish microgreen and clover etiolated sprouts semi-modified diet feeding for diabetic rats, the above damage was improved either for blood glucose or pancreatic cells, Also, Dehghani *et al* (2011) found that an aqueous extract Raphanus sativus treated rats shown normal pancreatic cells as compared with STZ diabetic rats.

3.6. Histopathological examination of rat liver

Histopathological examination of rat liver section under study are presented in Fig.1 (B). The section of the liver of normal rats showed normal appearance of histological structure (Fig. 1-B(a). The diabetic control (STZ-diabetic) rat's liver section showed atrophy of most of hepatocytes with individual cell necrosis with aggregation of inflammatory cells in –between hepatocytes especially lymphocytes Fig. 1-B(b). Similar results for more liver lymphocyte infiltration and inflammatory cells in diabetic rats than normal rats were obtained by Zafer *et al* (2009). The rats liver section from STZ induced diabetic, fed a diet with radish microgreen (radish microgreen diabetic group) showed individual cell necrosis (Fig. 1-B(c). The ECS diabetic group rats showed granular degeneration of the hypatocytes cytoplasm Fig. 1-D(d). The above results of liver histopathological examination are in agreement with those of liver function parameters. The stimulated activity of ALT and AST as well as increases in bilirubin in diabetic control were alleviated by feeding on clover etiolated sprout and radish microgreen semi-modified diets as treatments for diabetic influence.

3.7. Histopathological examination of rat kidneys

Histopathological examination of rat kidneys section under study are presented in Fig. 1 (C). The section of the kidneys of normal rat showed normal appearance of histological structure Fig. 1-C(a). STZ-diabetic rats kidneys section revealed vacuolar degeneration of epithelial lining of distal convoluted tubules. There was large number of lymphocytes aggregation in the interstitial tissues of medulla Fig. 1-C(b). The rats kidney section from STZ-diabetic, fed a diet with radish microgreen semi-modified diets showed the kidneys vacuolar degeneration of epithelial lining of some distal convoluted tubules Fig. 1-C(c). The cytoplasm of epithelial lining of tubules of the kidneys of clover etiolated sprout semi-modified diets – diabetic rats showed vascular degeneration Fig. 1-C(d). The present results of kidneys histopathological changes under the effects of diabetes are in paralleled with data obtained of urea, uric acid and creatinine as biomarkers for kidneys function. The three kidney parameters were increased in diabetic control, but by feeding on radish microgreen and clover etiolated sprouts semi-modified diets as diabetic treatments, these elevated values of urea; uric acid and creatinine were reduced those of normal control which may due to their vacuolar degeneration.

3.8. Histopathological examination of rat testes

Histopathological examinations of rat testis section under study are presented in Fig. 1 (D). The section of the testes of normal rats showed normal appearance of histological structure (Fig. 1-D(a). STZ- induced diabetic rats testes suffered from edema in-between seminiferous tubules which dispersed the tubules from each other's Fig 1-D(b). The germinal epithelium of some tubules was necrosis. Similar results for induction of diabetes caused destruction of histological normal testicular structure was also reported before by Ramzy et al (2014). The testis of rats of radish microgreen semi-modified diets- diabetic appeared normal Fig 1-D(c). Also, testis of rats of clover etiolated sprouts semi-modified diets-diabetic showed normal appearance Fig. 1-D (d). These abnormal testes of diabetic rats were improved under the treatment by clover etiolated sprouts and radish microgreen semi-modified diets.

ETHICAL APPROVAL

"All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee".

COMPETING INTERESTS

Authors have declared that no competing interests exist.

Table 1: Effect of seed sprouting on vitamin a and c, phenols, flavonoids and sugar profile of radish microgreen and etiolated sprouts vs seed.

Characters	Radish		Clover		LSD
	Seed	**microgreen**	**Seed**	**etiolated**	**0.05**
Vitamin A (â Carotene) mg/100g	0.26 b	2.40 a	0.25 b	0. 19 b	0.493
Vitamin C (Ascorbic acid) mg/100g	18.90 b	73.90 a	8.83 c	20.91 b	6.919
Total phenols (mg/g)	1.04 b	1.63 a	1.43 ab	1.65 a	0.422
Total flavonoids (mg/g)	0.09 b	0.37 a	0.13 b	0.16 b	0.101
Total sugars (%)	11.01 c	21.99 b	31.97 a	18.11 b	4.417
Soluble sugar (%)	5.91 c	12.27 ab	15.88 a	10.16 b	3.947
Non-soluble sugar (%)	5.10 b	9.72 b	16.09 a	7.95 b	5.857

Means in each row followed by the same letter are not significantly different at the 5% level.

Table 2: Effect of radish microgreen and clover etiolated sprout semi-modified diets on blood glucose, serum liver and kidney function parameters.

Treatment	Glucose mg/dl	Liver function			Kidney function		
		AST U/L	ALT U/L	Bilirubin mg/dl	Urea mg/dl	Uric acid	Creatinine mg/dl
G1-Normal control	142 b	89.0 c	30.7 b	0.267 a	50.5b	4.23 a	0.646 a
G2-Diabetic control(+STZ)	544 a	117.0 a	39.2 a	0.350 a	68.1a	2.98 c	0.546b
G3-Normal radish microgreen	141 b	90.7 c	29.3 b	0.283 a	52.2b	3.63 abc	0.635 a
G4-Diabetic radish microgreen(+STZ)	172 b	103.0 b	29.3	0.267 a	52.0b	3.73 ab	0.566 b
G5-Normal clover etiolated sprout	142 b	90.8 c	28.7 b	0.300 a	59.8ab	4.04 ab	0.686 a
G6-Diabetic clover etiolated sprout(+STZ)	178 b	98.8 bc	28.8 b	0.283 a	60.30b	4.29 a	0.557 b
LSD 0.05	71.28	11.15	4.98	0.1005	13.11	0.729	1.0666

Means in each column followed by the same letter are not significantly different at the 5% level.

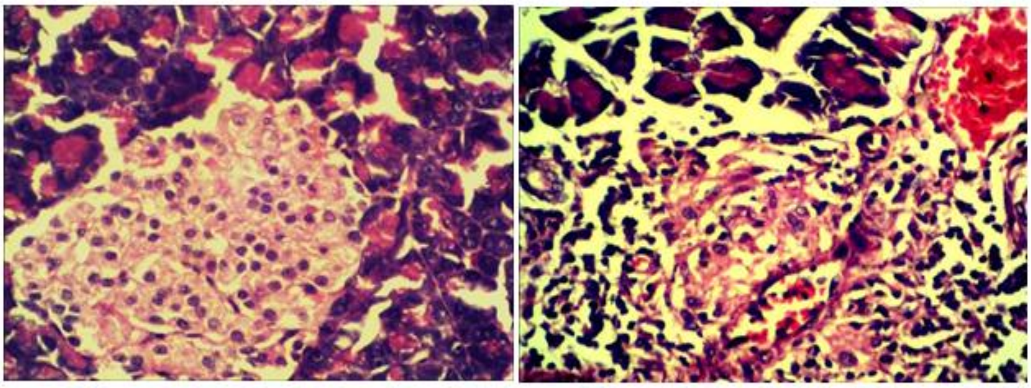
Figure ligands

Fig. 1A. Histopathological changes of Pancreas. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

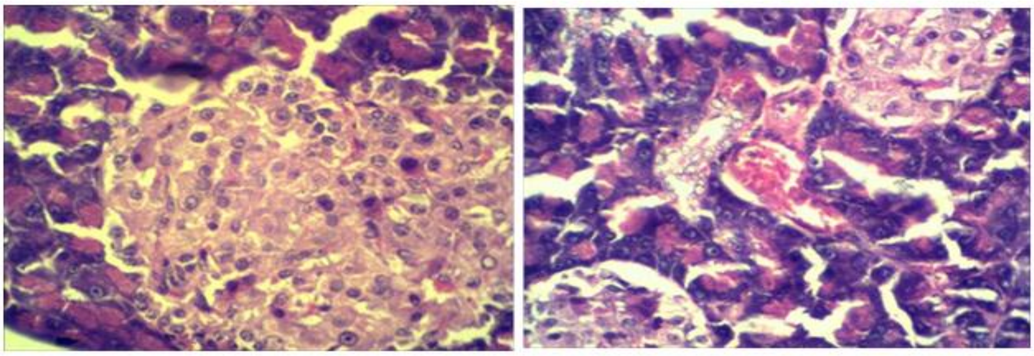
Fig. 1B. Histopathological changes of Liver. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

Fig. 1C. Histopathological changes of Kidneys. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

Fig. 1D. Histopathological changes of Testes. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

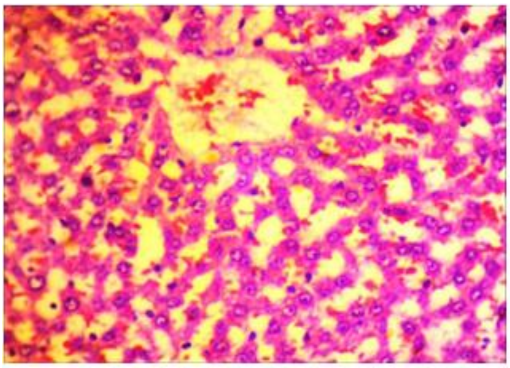
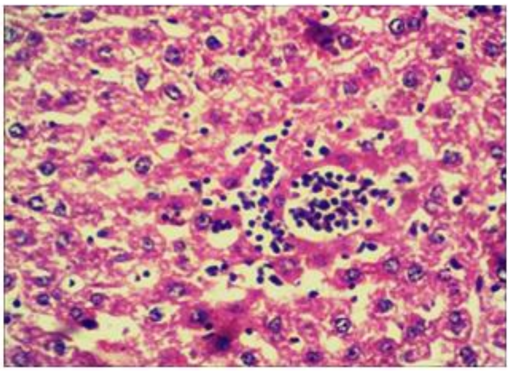


(A-a) **(A-b)**



(A-c) **(A-d)**

Fig 1A: Histopathological changes of Pancreas. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

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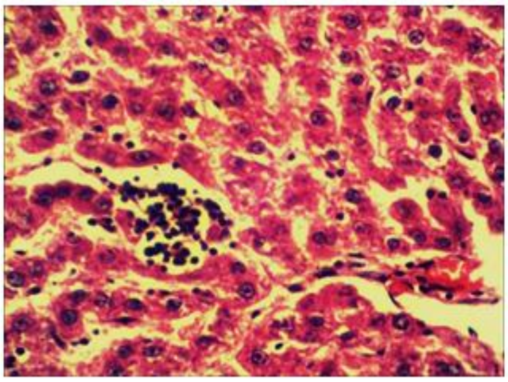
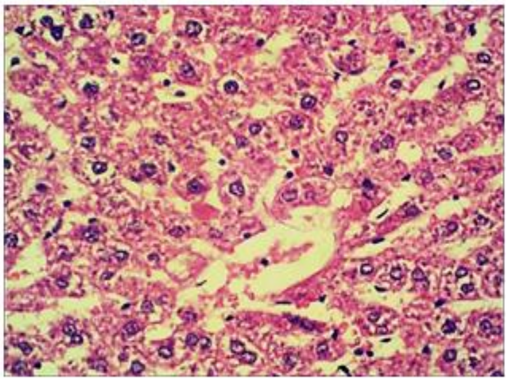
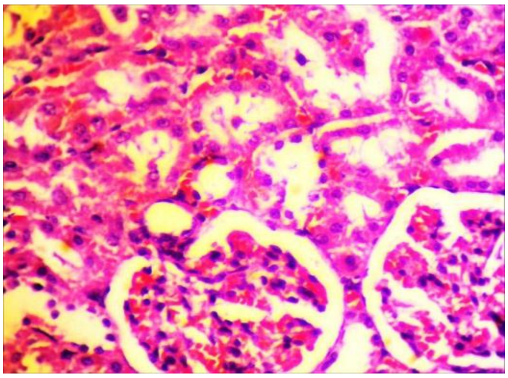
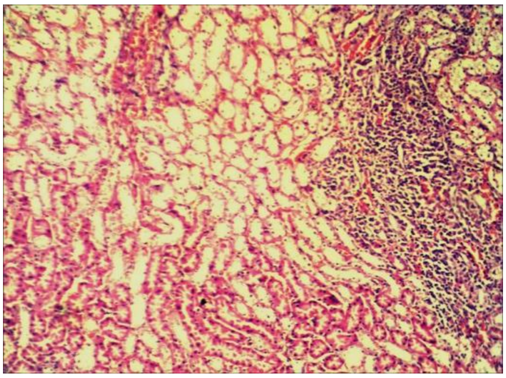
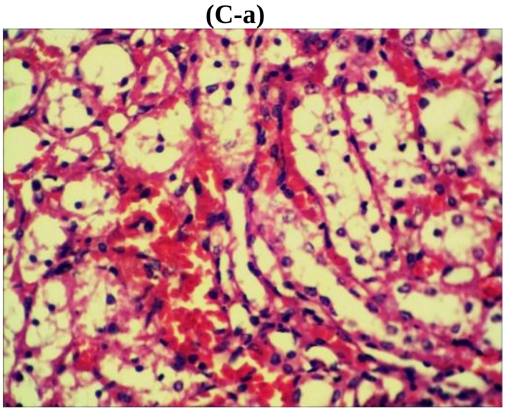
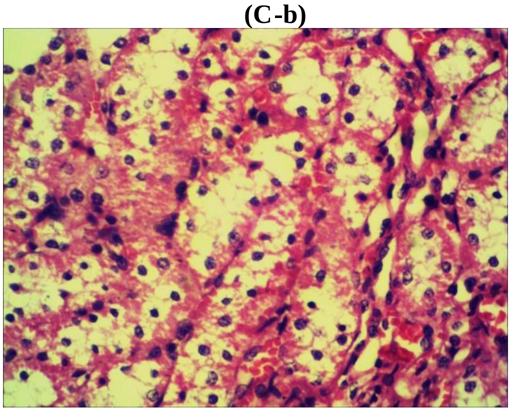



(B-c) **(B-d)**

Fig. 1B: Histopathological changes of Liver. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

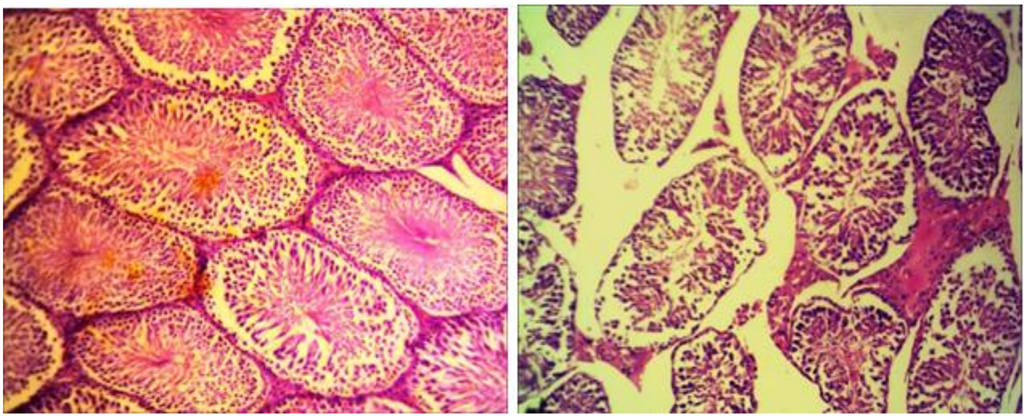



(C-a) **(C-b)**

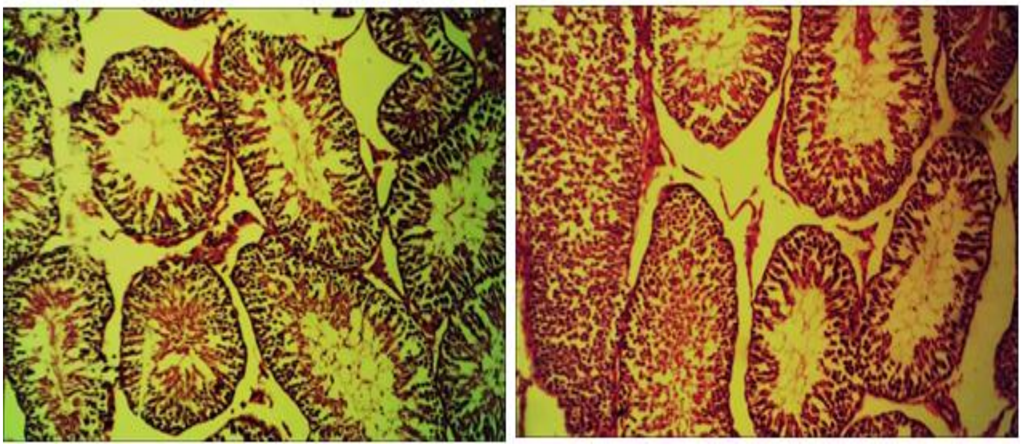



(C-c) **(C-d)**

Fig. 1C: Histopathological changes of Kidneys. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.



(D-a) (D-b)



(D-c) (D-d)

Fig. 1D: Histopathological changes of Testes. (A-a) Normal control, (A-b) Diabetic control, (A-c) Diabetic rats feeding by radish microgreen semi-modified diets and (A-d) Diabetic rats feeding by clover etiolated sprout semi-modified diets.

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