# Hypoglycemic and HypolipidemicActivities of Red Cabbage and Manganese in Diabetic Rats

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**Abstract:** This research occurred to study the effect of red cabbage leaves and manganese consumption on diabetic rats. Forty two Sprague Dawley adult male rats were injected with a single intraperitoneal dose of 60mg/kg of streptozotocin to induce diabetes then classified into control (+ve) and five treated groups which were red cabbage powder, red cabbage extract, manganese, red cabbage powder with manganese and red cabbage extract with manganese rat groups. Our results revealed that red cabbage powder, red cabbage extract, red cabbage powder with manganese and red cabbage extract with manganese rat groups showed a significant increased in weight gain, food efficiency ratio and protein efficiency ratio but significant decreased in serum creatinine and urea compared with control (+ve) rat group. Also, values of glucose, hemoglobin and liver function enzymes were significantly decreased while insulin was significantly increased in all treated groups. Lipid parameters were significantly decreased in serum and liver while serum high density lipoprotein cholesterol, liver glycogen, triglyceride, glutathione peroxidase and superoxide dismutase values were significantly increased in all treated groups compared with control (+ve) rat group. In conclusion, the hypoglycemic and hypolipidemic activities of red cabbage and manganese could offer a potential therapeutic effect for the treatment of diabetes in rats.
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**Key words:**Red cabbage, Manganese, Diabetes mellitus, Rats.

## 1. Introduction:

Diabetes mellitus is a chronic disease characterized by disorders in metabolism of carbohydrates, lipids and several essential trace elements. Preventionof diabetes still lies in the realm of future and until then tens of millions will continue to suffer from this disease **(Kazi et al., 2008)**. Diabetes is one of the trust areas of research for finding natural drugs with hypoglycemic activity. Herbal drugs have less toxicity with fewer side effects compared with synthetic drugs (**Kameswara et al., 1997)**.

High fruit and vegetable consumption has been associated with a decreased risk of cardiovascular diseases including ischemic heart disease, stroke and coronary heart disease **(Halvorsen et al., 2002)**. Red cabbage (Brassica oleracea) belongs to the cruciferous, or Brassica, family that includes broccoli, turnips and Brussels sprouts. Red cabbage is red hue and bitter, peppery flavor. Cruciferous vegetables are the only source of sulfur-containing compounds called glucosinolates that are responsible for their bitter flavor. Glucosinolates are digested into isothiocyanates that reduce inflammation and fight bacteria. The red pigment comes from a flavonoid, cyanidin, that functions as an antioxidant. In addition to these important phytochemicals, cabbage contributes to overall health with fiber and a range of vitamins and minerals **(Igarashi et al., 2000 and Jagdish et al., 2006)**.

Manganese is one of the essential trace metals, a necessary dietary constituent obtained from nuts, seeds, and whole-grain cereals. It is necessary for bone growth and development, reproduction, lipid metabolism and the moderation of nervous irritability. Manganese is essential for glucose metabolism and deficiency may result in glucose intolerance similar to diabetes mellitus in some animal species. Manganese has a potent insulinomimetic effect in correcting a number of key metabolic abnormalities associated with the feeding of high fat diets **(Walter *et al*., 1991 and Baquer*et a.l,* 2003)**.

In the present work, we examined the effects of red cabbage and manganese on streptozotocin induced diabetic in rats.

## 2 Materials And Methods:

A total of 42 Sprague-Dawly male rats weighting 150 ± 7 g were provided from experimental animals' center in Medicine collage of King Saudi University in Riyadh.Animals were housed in cages underconditions of controlled temperature (22- 28ºC) and12-h artificial light period for 10 days before andduring of experiments and had free access basal diet.Red cabbages were purchased from local market in Riyadh, Saudi Arabia. The outer layer was removed but the inner were cut into small pieces, dried at 60°C in hot oven and crushed to a fine powder. Protein, fat, dietary fiber and ash

contents were determined while carbohydrate was calculated by differencein red cabbageaccording to **A.O.A.C. (2005)** methods. Red cabbage powder was added as 10% of basal diet. The cabbage powdered leaf (100g) was soaked in 600ml of 80% methanol with constant stirring by a magnetic stirrer for 48 hr. The mixture was filtered followed by removal of the solvent on the rotatory evaporator to give a dark-brown crude extract. The rat received cabbage extract in 100 mg kg/body weight by stomach tube. Manganese sulphate (MnSO4) was purchased from Gomoheria Company. The rat dose of MnSO4 was 10mg/kg. Diagnostic kits were manufactured by Ranbaxy Diagnostics Ltd., were purchased from the Gamma Trade Company for Pharmaceutical and Chemicals. The rat basal diet was performed according to **Reeves et al., (1993)**.

Animals becamediabetic by i.p. injection of streptozotocin (60mg/kg) and were divided randomly into six groups which were control (+ve) and five treated groups which werered cabbage powder, red cabbageextract, manganese, red cabbage powder withmanganese andred cabbage extract with manganese rat groups. The treatment period was 60 days. Daily food intake and weekly body weight gain were recorded.Feed efficiency ratio (FER) and protein efficiency ratio (PER) were determined by **Chapman et al., (1950)**.After 24 h of last dose,animals wereanesthetized by ether and blood samples werecollected from tail vein for evaluation of glucose andhemoglobin was estimated in heparenized blood according to **Sasaki et al., (1972) and Drabkin(1949)**, respectively. Serum insulin and glucosalatedheamoglobin (HbA1C %) were estimated according to**Wilson and Miles (1977) and Abraham et al., (1978)**, respectively.Serum alanine and aspartate amino transferase (ALT&AST), serum alkaline phosphatase (ALP) enzymes ; creatinine and ureawere estimated by using commercially available kits according to **Reitman and Frankel (1957), Kind and King (1954) , Bonsens and Taussky, (1984) and Patton and Crouch,(1977),** respectively. Serum cholesterol (CHO), triglycerides (TG) and high density lipoprotein cholesterol ($HDL\text{-}_C$) were determined by using enzymatic colorimetric methods **(Abell et al., 1952, Buccolo and David 1973 and Kostener 1977,** respectively). Liver cholesterol (CHO), total lipids, triglyceride and glycogen were determined according to **Richmond (1973), Folch et al., (1957), Scheletter and Nussel (1975) and Rerup and Lundquist (1967),** respectively.The level of liver glutathione peroxidase (GPX), superoxide dismutase (SOD), and malondialdehyde (MDA) activity was determined by the method of**Weiss et al., (1980), Misra and Fridovich (1972) and Uchiyama and Mihara (1978)** ,respectively. Low density lipoprotein cholesterol (LDL-c)**,**verylow density lipoprotein cholesterol (VLDL-c) and CHO/ HDL-c were calculated according to **Fruchart (1982) and Castelli and levitar, (1977)**, respectively.

All the results were expressed as Mean ± SD. The statistical analysis was carried out by one-way ANOVA followed by Dunnett's multiple comparison tests. $P < 0.05$ was considered as Significant **(Artimage and Berry 1987)**.

**3. Results and Discussion:**

Our results revealed that the proximate component of dried red cabbage was presented in Table 1. The dried cabbage contained 13.99±1.33, 0.85±0.02 and14.61±1.45 g/100g of protein,fat and fiber, respectively. Meanwhile, the dried cabbage content of carbohydrate and moisture were64.54±3.71 and6.01±1.55, respectively. These results were agreed with **Kahlonet al., 2008**who found that the total dietary fiber (27.3%), protein (22.8%), fat (0.9%), ash (8.4%) and Carbohydrate (67.9%) content of cabbage as dry matter.

Redcabbage powder, red cabbage extract, red cabbage powder with manganese and red cabbage extract with manganese rat groups showed a significant increased in weight gain, FER and PER at $P<0.01\&<0.001$ while manganese rat group showed a significant increased in weight gain, and FER at $P<0.01$comparing to control (+ve) rat group. Food intake was similar in all experimental rat groups as shown in table (2). These results were agreed with**Hazem and AlaaEldin2010** who found that rats that ingested red cabbage extract showed no significant changes as compared with normal control rats in any of the parameters. Red cabbage is a very good source of fiber. It is an excellent source of vitamin C,A,B6and vitamin Kand a good source of manganese. **Baquer*et al.,* 1982 and2003** reported thatmanganese has an insulinomimetic action via a role in insulin second messenger generation.

Values of glucoseand $HbA_{IC}$ were significantly decreased in all treated rat groups while insulin and HG were significantly increased in all treated groups ($P<0.01$ &0.001) compared with control (+ve) rat group. There was non-significant difference in glucose, HG, insulin and $HbA_{IC}$ between red cabbage powder with manganese and red cabbage extract with manganese rat groups. Also, there were non significant difference in insulin, HG and $HbA_{IC}$ among red cabbage powder, red cabbage extract and manganese rat groups as shown in table (3). The obtained results were agreed with **Abd EI-Ghany (2002) and Gagliardino(2005)** who recorded that diabetes mellitus is a syndrome characterized by abnormal insulin secretion, derangement in carbohydrate and lipid metabolism, and is diagnosed

by the presence of hyperglycemia, which causes a number of complications like cardiovascular, renal, neurological and ocular. **Dallatu et al., 2010** reported that Mn is essential for glucose metabolism and deficiency may result in glucose intolerance similar to diabetes mellitus in some animal species. Diabetic patients showed lower level of Mn than that of normal nondiabetic subjects but the difference did not reach to the level of statistically significant difference.

Values of serum ALT, AST and ALP were significantly decreased in all treated groups (P<0.01 & 0.001) compared with control (+ve) rat group. Serum ALT, AST and ALP were significantly increased in red cabbage powder, red cabbage powder with manganese and red cabbage extract with manganese groups compared with manganese group as shown in table (4). **Baquer *et al.*, (2003**) reported that manganese treatment suppressed the developmental changes in liver and adipose tissue with respect to the emergence of clusters of enzymes linked to glucose oxidation and lipogenesis. **Subasinghe *et al* (1985)** found that Mn2+ may act like insulin in increasing the transport of glucose into adipose tissue either by enhancing an existing low level of insulin , like chromium ions or by having insulin-like action on the cell membrane as has been shown for a number of other transition metal ions

Our results revealed that serum creatinine was significantly decreased in red cabbage powder, red cabbage extract, red cabbage powder with manganese and red cabbage extract with manganese rat groups at P<0.001 while serum urea was significantly decreased in all treated groups at P<0.001 compared with control (+ve) rat group. Serum creatinine was significantly increased in red cabbage powder and red cabbage extract rat groups compared with red cabbage powder with manganese and red cabbage extract with manganese groups. There was a non significant difference in urea among treated groups as shown in table (5). These results were explained by **Walter et al., 1991** who recorded that Mn2+ and insulin both cause an increased oxidation of carbon-1 of glucose into CO2 and an increase in its incorporation into lipids. The effects of these two agents are found to be additive in control rats.

Values of serum LDLc, T.G and VLDLc were significantly decreased in all treated groups (P<0.01 & 0.001) compared with control (+ve) rat group. Serum LDLc was significantly increased in red cabbage powder and red cabbage extract compared with red cabbage powder with manganese rat group and significantly decreased compared with manganese group. Serum T.G showed non significant difference among treated groups while serum VLDLc was significantly increased in manganese rat group as shown in table (6). **El Yazigi et al., 1991** recorded that manganese is an important cofactor in the key enzymes of glucose metabolism. It has been found that a deficiency results in diabetes in guinea pigs as well as the frequent birth of off spring that develop pancreatic abnormalities or no pancreas at all. Mn2+ alone was also found to decrease glycerol release in both control and diabetic adipose tissue.

Values of serum cholesterol and cholesterol/ HDLc ratio were significantly decreased (P<0.01 &0.001) but serum HDLc was significantly increased (P<0.001) in all treated groups compared with control (+ve) rat group. Serum cholesterol was significantly increased in manganese rat group compared with other treated rat groups while serum HDLc showed a non significant difference among treated groups as shown in table (7). **Valko et al., 2007** recorded that high fruit and vegetable intake may help control diabetes, obesity, high cholesterol and hypertension because there are many beneficial dietary components in fruits and vegetables including vitamins, minerals, fiber and phytochemicals that may be responsible for their health benefits. **Waqar and Mahmood (2010)** reported the ethanolic extract cabbage caused reduction in serum LDL, while increased HDL significantly. **Viktorinova et al., (2008)** reported that manganese treatment was able to override the effects of a high fat diet on the activity of enzymes of carbohydrate and lipid metabolism in various tissues of rat. Adequate intake is required for the lipid and glucose metabolism and oxidative phosphorylation. On normal lipid metabolism manganese has a beneficial effect, particularly in cases of atherosclerosis.

Values of liver GPX and SOD were significantly increased (P<0.01 &0.001) but liver MDA was significantly decreased (P<0.01 & 0.001) in all treated groups compared with control (+ve) rat group. Value of liver GPX was significantly increased in red cabbage powder with manganese and red cabbage extract with manganese rat groups compared with red cabbage powder and manganese rat groups while liver SOD was significantly decreased in manganese group compared with red cabbage extract, red cabbage powder with manganese and red cabbage extract with manganese. Liver MDA showed a non significant difference among treated groups as shown in table (8). **Bambolkar and Sainani 1995** reported that oxidative stress is reported to be increased in patients with diabetes mellitus. Red cabbage has even higher quantities of antioxidant protection from many phytonutrients, particularly polyphenols including anthocyanins. Red cabbage has 56 percent of the recommended daily intake of this important vitamin. As an antioxidant, vitamin C fights inflammation and protects cells from

damage that leads to chronic health conditions, such as heart disease. Vitamin C also strengthens the immune system by stimulating the production of white blood cells that fight invading bacteria and infections. **Kameswara et al., 1997 and Genet et al., 2002** reported thatthere are many enzymatic and nonenzymatic antioxidant defence systems in the body that remove these toxic species. Enzymes such as superoxide dismutase, catalase, glutathione peroxidase, etc. are involved in this detoxification process. Oxidative stress has been shown to have a role in the causation of diabetes type I and II and as such antioxidants may have a role in the alleviation of diabetes and related problems. Manganese plays a role as a cofactor for the antioxidant enzyme, MnSOD, whose levels are reported to be lower in thediabetic.

Values of liver cholesterol and total lipid were significantly decreased (P<0.01 &0.001) while glycogen and TG values (P<0.01&0.001) were significantly increased in all treated groups compared with control (+ve) rat group. There were non significant difference in value of liver cholesterol among treated groups and also both total lipids and TG among red cabbage powder, red cabbage extract, manganese and red cabbage powder with manganese rat groups as shown in table (9). Epidemiological data as well as in vitro studies strongly suggest that cabbage having antioxidant photochemical compound have strong protective effects against major degenerative diseases including cardiovascular diseases, antihyperglycemic and hypocholesterolemic **(Baynes 1991, Roman-Ramos *et al.*, 1995 and Komatsu *et al.*, 1998)**.

It is advanced to consume red cabbage and manganese todiabeticpatients for their nutritional and hypoglycemic effects.

Table (1): The proximate components (g/100g) of dried cabbage

| Red cabbage | Protein | Fat | fiber | Carbohydrates | Moisture |
|---|---|---|---|---|---|
| component | 13.99±1.33 | 0.85±0.02 | 14.61±1.45 | 64.54±3.71 | 6.01±1.55 |

Means ± standard deviation of means of three determinations.

Table (2): Mean values ± SD of body weight gain, food intake, FER and PER of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| Weight gain (g) | 37.71± 3.21$^{c}$ | 57.91± 4.64$^{b**}$ | 71.45± 6.96$^{a***}$ | 48.71± 4.65$^{b**}$ | 68.71± 6.88$^{a***}$ | 75.71± 8.61$^{a***}$ |
| Food intake(g/w) | 16.51± 1.49$^{a}$ | 17.70± 1.4a | 17.88± 1.34$^{a}$ | 18.11± 1.41$^{a}$ | 18.41± 1.25$^{a}$ | 17.89± 1.31$^{a}$ |
| FER | 0.038± 0.005$^{e}$ | 0.054± 0.004$^{c**}$ | 0.066± 0.002$^{ab**}$ | 0.044± 0.001$^{cd**}$ | 0.062± 0.003$^{b***}$ | 0.070± 0.002$^{a**}$ |
| PER | 0.190± 0.04$^{d}$ | 0.272± 0.01$^{bc*}$ | 0.333± 0.03$^{ab**}$ | 0.224± 0.02$^{d}$ | 0.312± 0.03$^{ab**}$ | 0.353± 0.02$^{a***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
$^{abcd}$Mean values in each raw having similar letters were not significantly different.

Table (3): Mean values ± SD of serum glucose, insulin, HG and HbAIC of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| Glucose (mg/dl) | 295.71±15.33$^{a}$ | 181.41±11.21$^{b**}$ | 163.45±12.41$^{c**}$ | 170.31±13.65$^{bc**}$ | 140.32±10.21$^{d***}$ | 131.41±11.77$^{d***}$ |
| Insulin (µ/l) | 8.61±1.11$^{c}$ | 11.41±1.03$^{b**}$ | 12.71±1.60$^{b**}$ | 12.96±1.21$^{b**}$ | 14.11±1.73$^{a***}$ | 14.50±1.33$^{a***}$ |
| HG (g/dl) | 10.61±1.16$^{c}$ | 13.21±1.41$^{ab**}$ | 13.96±1.35$^{ab**}$ | 12.21±1.26$^{b**}$ | 14.11±1.45$^{a***}$ | 14.31±1.51$^{a***}$ |
| HbAIC % | 8.41±0.88$^{a}$ | 5.70±0.57$^{b**}$ | 5.17±0.66$^{b***}$ | 5.57±0.44$^{b**}$ | 5.11±0.54b$^{***}$ | 4.99±0.77$^{b***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
$^{abcd}$Mean values in each raw having similar letters were not significantly different

Table (4): The Mean values ± SD of serum ALT, AST and ALP enzymes of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| ALT (µ /ml) | 48.71±0.88$^{a}$ | 29.96±2.73$^{c**}$ | 31.78±3.21$^{bc***}$ | 35.71±4.71$^{b**}$ | 27.26±2.14$^{c***}$ | 28.75±2.11$^{c***}$ |
| AST (µ /ml) | 59.67±5.27$^{a}$ | 32.71±3.21$^{c***}$ | 35.07±4.76$^{bc***}$ | 39.67±4.35$^{b***}$ | 35.44±4.23b$^{c***}$ | 33.60±3.11$^{c***}$ |
| ALP (µ /ml) | 53.67±5.41$^{a}$ | 34.71±3.20$^{c***}$ | 41.71±5.60$^{b**}$ | 40.16±4.67$^{b**}$ | 32.40±3.71$^{c***}$ | 30.41±3.35$^{c***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
$^{abcd}$Mean values in each raw having similar letters were not significantly different

Table (5): The Mean values ± SD of serum creatinine and urea of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| Creatinine (mg/dl) | $1.55\pm0.17^{a}$ | $0.89\pm0.04^{b***}$ | $0.78\pm0.04^{bc***}$ | $1.15\pm0.23^{a}$ | $0.77\pm0.03^{c***}$ | $0.59\pm0.01^{a***}$ |
| Urea (µ /mg) | $58.63\pm6.11^{a}$ | $40.33\pm5.14^{b***}$ | $38.65\pm3.18^{b***}$ | $41.45\pm4.37^{b***}$ | $35.16\pm4.20^{bc***}$ | $37.81\pm5.11^{b***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
[abcd]Mean values in each raw having similar letters were not significantly different.

Table (6): The Mean values ± SD of serum LDLc, TG and VLDLc of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| LDLc (mg/g) | $147.91\pm17.91^{a}$ | $83.23\pm8.21^{c***}$ | $79.65\pm8.96^{c***}$ | $110.06\pm11.21^{b**}$ | $67.42\pm7.27^{d**}$ | $70.34\pm8.44^{cd***}$ |
| T.G (mg/g) | $80.71\pm9.61^{a}$ | $54.70\pm6.71^{b***}$ | $51.60\pm6.17^{b***}$ | $53.71\pm5.81^{b***}$ | $49.40\pm5.37^{b***}$ | $50.41\pm5.33^{b***}$ |
| VLDLc (mg/g) | $16.14\pm1.21^{a}$ | $4.02\pm0.79^{bc***}$ | $3.96\pm0.81^{c***}$ | $5.10\pm0.45^{b**}$ | $3.33\pm0.57^{c***}$ | $3.45\pm0.66^{c***}$ |

Table (7): The Mean values ± SD of serum CHO, HDLc and cholesterol/ HDLc ratio of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| CHO (mg/g) | $185.41\pm21.36^{a}$ | $125.31\pm12.15^{c***}$ | $120.31\pm13.04^{c***}$ | $150.21\pm15.30^{b**}$ | $110.41\pm10.45^{c***}$ | $113.13\pm11.10^{c***}$ |
| HDLc (mg/g) | $21.38\pm2.59^{b}$ | $31.14\pm3.17^{a***}$ | $30.34\pm4.34^{a***}$ | $29.41\pm3.22^{a***}$ | $33.11\pm4.07^{a***}$ | $32.71\pm4.36^{a***}$ |
| CHO/ HDLc | $8.67\pm1.21^{a}$ | $4.02\pm0.79^{bc***}$ | $3.96\pm0.81^{c***}$ | $5.10\pm0.45^{b**}$ | $3.33\pm0.57^{c***}$ | $3.45\pm0.66^{c***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
[abcd]Mean values in each raw having similar letters were not significantly different.

Table (8): The Mean values ± SD of liver GPX, SOD and MDA of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| GPX (µ /mg) | $17.65\pm2.42^{c}$ | $30.77\pm4.17^{b***}$ | $34.47\pm3.99^{ab**}$ | $31.20\pm4.27^{b***}$ | $35.33\pm6.01^{a***}$ | $37.64\pm5.21^{a***}$ |
| SOD (µ /mg) | $20.27\pm2.22^{c}$ | $38.51\pm3.36^{ab***}$ | $41.27\pm4.07^{a***}$ | $35.71\pm5.30^{b***}$ | $42.71\pm5.61^{a***}$ | $40.71\pm5.55^{a***}$ |
| MDA (µ/mg protein) | $17.96\pm2.71^{a}$ | $9.11\pm0.99^{b**}$ | $8.33\pm1.36^{bc***}$ | $10.14\pm1.10^{b**}$ | $8.67\pm2.16^{bc**}$ | $7.14\pm1.33^{c***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
[abcd]Mean values in each raw having similar letters were not significantly different.

Table (9): The Mean values ± SD of liver cholesterol, total lipids, glycogen and triglyceride of the experimental rat groups

| Groups Variables | Control (+ve) | Red cabbage powder | Red cabbage extract | Manganese | Red cabbage powder with manganese | Red cabbage extract with manganese |
|---|---|---|---|---|---|---|
| CHO (mg/g) | $7.33\pm1.21^{a}$ | $4.11\pm0.67^{b**}$ | $4.96\pm0.56^{b**}$ | $5.14\pm0.77^{b**}$ | $4.21\pm0.88^{b**}$ | $3.77\pm0.45^{bc***}$ |
| T.lipids (mg/g) | $45.96\pm4.14^{a}$ | $35.60\pm3.77^{bc}$** | $36.11\pm5.17^{b**}$ | $37.61\pm4.24^{b**}$ | $34.21\pm5.17^{bc**}$ | $33.77\pm4.36^{c***}$ |
| Glycogen (mg/100g) | $5.17\pm1.10^{c}$ | $7.99\pm1.36^{b**}$ | $8.11\pm1.24^{ab***}$ | $7.31\pm1.33^{b***}$ | $9.11\pm1.51^{a***}$ | $9.41\pm1.61^{a***}$ |
| TG (mg/g) | $1.71\pm0.34^{c}$ | $2.51\pm0.65^{ab**}$ | $2.12\pm0.77^{b**}$ | $1.99\pm0.44^{bc}$ | $2.66\pm0.87^{ab**}$ | $3.17\pm0.85^{a***}$ |

Significant with control group * P<0.05 ** P<0.01 *** P<0.001.
[abcd]Mean values in each raw having similar letters were not significantly different

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