Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E Ghozy¹ and Rehab Ibrahim Tag Al Deen²

¹Home Economics Dept., Faculty of Specific Education, Mansoura university, Egypt.
²Home Economics Dept., Faculty of Specific Education, Zagazig University. Egypt.

ABSTRACT

Recently, red radish sparked much interest in health and nutrition. So this study aimed to clarify the effect of red radish roots juice on obese rats. The chemical analysis of the phenolic content and antioxidant activity of the red radish roots juice were determined. An experiment performed on 36 male rats distributed into 6 equal groups. The first group kept as normal control, fed on a basal diet. While other groups fed on a high-fat diet to induce obesity. Obese rats, group (2) left as a positive control. Three obese groups (3, 4 and 5) received red radish roots juice (1, 2 and 3 ml/kg BW/day) with a high-fat diet. After 6 weeks, biological parameters (feed intake FI, body weight gain BWG, body mass index BMI, and Feed efficiency ratio FER) calculated, and biochemical analysis (serum leptin, adiponectin, oxidative stress, tumor necrosis factor-alpha (TNFα), total antioxidant capacity, and lipid profile) estimated. Results confirmed that a high level of ferric reducing antioxidant (FRAP) and total radical-trapping antioxidant parameter (TRAP) in a positive control group. Red radish roots juice affected a significant decrease in leptin, adiponectin, TNF-α, and total oxidant capacity, while increasing the total antioxidant capacity as compared to the positive control group. Also, lipid profile normalization showed in group 5 that received a high-fat diet plus 3 ml red radish roots juice. Therefore, this study concluded that the consumption of red radish as a functional food for a delay may protect the risk of adipose tissue.

Key words: Adipose tissue, Red radish, Anti-inflammatory, Body mass index
INTRODUCTION

Obesity is defined as excess adipose tissue and BMI value is higher than 30. BMI is an indicator that measures weight compared to height. Excess fat tissue led to severe health consequences such as diabetes, high blood pressure, and high blood lipids. Obesity between 40% and 70% is due to different genetic factors, not environmental or lifestyle factors. As research in mice has shown, there are 5 genes linked to appetite, which lead to obesity (Beopoulos et al., 2009). These genes are also present in humans. Leptin is one of the main genetic factors in obesity. Obesity is one of the main risks of metabolic diseases due to chronic inflammation. Irregular production of inflammatory cytokines is known by excessive adipose tissue on humoral mediators derived from anti-inflammatory adipose tissue (fatty acids such as adiponectin) to induce a condition referred to as insulin resistance. Recently, naturally occurring antioxidant components are instrumental in dismantling free radiation and protecting health (Gutiérrez and Perez 2017). No sufficient scientific proof for the antidiabetic, anti-obesity and anti-cholesterol activity of plants. However, plant products can improve not only glucose metabolism but also improves lipid metabolism, antioxidant status, and capillary function (Zhu et al., 2012).

Radish (Raphanus sativus) the family (Cruciferae) is a radical crop. It comes in a variety of colors including white, red, purple, or black, and informal. It can be long, cylindrical, or circular. It may be eaten raw, cooked, or pickled. The oil obtained from radish seeds is also used in several useful health applications. Red radish is one of the oldest known foods, used by the Pharaohs and Greece (Otsuki et al., 2004 and Tamura et al., 2010). Red radish contains many important vitamins and minerals (folic acid, anthocyanins; potassium, calcium, copper, iron, phosphorus, and zinc);
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

Bulletin of the National Nutrition Institute of the Arab Republic of Egypt. December 2019 (54) 3

fiber, and antioxidants components, these elements make it rich in many benefits including liver activation, detoxification, and protect the liver from cancer (Cheon and Kim 2014 and Anna et al., 2016). It also works on diuresis, regulating bile production; activating enzymes; lowering high blood pressure and cholesterol level; reducing hyperglycemia; sexual dysfunction; softening and moisturizing skin; strengthens and density bones; expels worms from the intestines and improves overall health (Pu Jing et al., 2014).

MATERIALS AND METHODS

Materials: -
Casein, vitamins, minerals, cellulose, starch purchased from a local distributor of (Sigma Chemical Co) Cairo, Egypt. Red radish (Raphanus raphanistrum subsp. Sativus L.) and tallow purchased from a local market. Adult male albino rats (Sprague- Dawley strain) (n = 30 rat) weighting approximately (180 ±5 g.) purchased from the Helwan Experimental Animals farm. Kits for blood analysis purchased from Gamma Trade Company, Dokki, Cairo, Egypt.

Methods: -
Preparation of fresh red radish roots juice:
Red radish roots were washed thoroughly with tap water and homogenized by a household blender. The juice collected using suction filtration through filter papers, then stored at -20°C until used according to (Gyamfi, et al., 2011).
Total antioxidant capacity
Ferric reducing antioxidant power (FRAP) and total radical-trapping antioxidant parameter (TRAP) assay determined in red radish extract according to (Pellegrini et al., 2003, Benzie and Strain, 1999 and Ghiselli et al., 1995). The TRAP and TEAC values expressed as micromoles of Trolox per g of plant extract while FRAP values expressed as
micromoles of Fe2+ equivalents per g of plant extract.

**HPLC analysis of polyphenols and flavonoids:**

40 mg of extract sample dissolved in acidified methanol (10 mL, 1% formic acid). The extract kept at −20 °C in the dark. The content of the phenolic determined accordingly method of (Singleton and Rossi, 1965). The data were calculated according to (Zhishen, et al., 1999), and expressed as mg of catechin equivalents (CE) per gram of extract.

**Induction of obesity:**

Rats fed four weeks on basal diet according to (Reeves, et al., 1993) with some modification in fat content containing: casein 14%, cellulose 5%, vitamin mixture 1%, mineral mixture 3.5%, sucrose 10%, (tallow 19% +soybean oil 1%), l-cystine 0.18, choline bitartrate0.25% and the remainder is starch to induce obesity in rats (Liu, et al., 2010).

**Biological study:**

Thirty-six adult male Sprague-Dawley rats were fed on standard diet for one week for adaptation. Rats were randomly divided into five groups (6 rats each) as follow: group one was fed on basal diet only and kept as negative control group, while groups (2, 3, 4 & 5) of rats (n=28) were fed on high fat diet for four weeks to induce obesity. These rats were then divided into three groups, positive control group and three curative groups given red radish orally 1 ml, 2 ml and 3 ml juice /Kg / BW / day respectively during the experimental period (6 weeks).

**Anthropometric measurements:**

The body weight of each animal was measured three times a week. The length of the animals was determined once a month by measuring distances (from the nose to anal) Jeyakumar et al., (2006). Body mass index (BMI) was estimated once after a month by the formula:
Effect of Fresh Red Radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E. Ghozy and Rehab Ibrahim Tag Al Deen

BMI = Body mass (g)/ [nose-anal distances (cm)]^2

LDL = TC - (HDL + TG/5).

During the experiment period, the quantities of diet, which consumed and / or wasted, were recorded every day. In addition, rat’s weight was recorded weekly to determine feed intake (FI) and body weight gain (BWG) % according to Chapman et al., (1959).

Biochemical analysis of serum:

Concentrations of serum leptin and adiponectin were measured according to (Beutler et al., 1985 and Yudkin, 2003) respectively. Serum “total antioxidants” and oxidant capacities and TNF-α were measured using standard spectrophotometric methods according to (Cao et al., 1993, Flohe and Gunzler, 1984 and Thorell, 1973), respectively. Serum TG, TC and HDL were determined according to (Fossati and Prencipe, 1982, Allain, 1974 and Burstein et al., 1970), respectively. Serum LDL value was calculated according to the equation of Friedwald et al., (1972).

Atherogenic Index = (Total cholesterol / HDL-cholesterol) were calculated according to the equation of Golay et al., (1990).

Statistical Analysis:

The obtained data statistically analyzed using computerized SPSS and 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 (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The results of the antioxidant activity of red radish juice (Table 1) reveals that they have potent antioxidant activity that represented by FRAP (1354.05 µmol Fe++/g) and TRAP (732.20 µmol TE/g) assays. These results are in agreement with the data obtained by Goyeneche, (2015) found that in red
radish were FRAP (1298.57 μmol Fe++/g) and TRAP (632.72 μmol TE/g).

The phytochemical screening of red radish method juice by HPLC analysis showed the presence of different phenolic compounds including gallic, pyrogallol, coumaric, catechin, caffeine, caffeic acid, vanillic and Protocatechuic acid compounds as indicated by the maximum absorption (λ<sub>max</sub>/nm) and retention times (Rt/min) of the phenolic standards (Table 2). It was reported that the red radish leaves and roots contained flavonoids, tannins, catechin, coumaric, vanillic caffeic acid, gallic, syringic, rutin and orotocatechuic acid which showed different pharmacological properties (Levine et al., 2010 and Im et al., 2018 and Yu et al., 2013). Tannins are the most antioxidants present in the human diet and they are involved in protection against degenerative diseases and oxidative stress, gallic acid showed potent antioxidant activity by preventing lipid per-oxidation (Goyeneche et al., 2015). Based on the obtained data, the red radish has antioxidant activity, related to the phenolic content which promoting possible health benefits; thus, it can serve as an excellent natural source of antioxidant agents.

Table (3) revealed that the differences in feed intake, body weight gain and body mass index (BMI) between rats belonging to different study groups were insignificant except for groups 4 and 5 which showed a significant reduction in feed intake in addition to significant decrease in body weight gain as well as the final BMI when compared to the untreated (+ve) group and curative group 3. From such that it could be noticed that the positive group (+ve) feed showed a significant increase in body weight gain (BWG), FER and (BMI) when compared to the normal group. Also, red radish in the curry was reported to inhibit body weight and adipocyte hypertrophy in obese rats (Goyeneche et al., 2015). The major groups of bioactive
components in selected herbs are flavonoids, carotenoids, and phenethylamine alkaloids.

The leptin hormone, adiponectin, TNF-α, total antioxidant capacity and total oxidant capacity of control and all the experimental rats’ groups are shown in Table (4). From the same table, it could be observed that the significant increase on the leptin, TNF-α, and Total oxidant capacity levels of positive control comparing with normal control but adiponectin and total antioxidant capacity values that were the significant decrease. There is marked increase in adiponectin and total antioxidant capacity of treatment groups’ while decreased in the level of leptin hormone of the same groups when compared to positive control group. In similar studies done by Zhao et al., (2008) and Haque et al., (2014) found that high fat diet raises a marked hypertrophy of brown and white adipose tissue. It seems that the effect of red radish powder on reducing leptin hormone is known to be due to its powerful antioxidant activities (Isabel, et al., 2018). Group 5 significantly has the highest adiponectin, total oxidant capacity, and total antioxidant capacity but it has the lowest Leptin and TNF-α compared to the other treatment groups’ revision in the table (Table 4). Although the TNF-α level in groups 5 was found to be the lowest among the study groups, the reduction was significant when compared with (+ve) group. These results confirm the antioxidant effect of red radish juice. This effect may be due to certain chemical constituents such as polyphenols or terpenes in red radish which possess good oxygen radical scavenging potential (Ferreira et al., 2011).

The lipids profile of all groups is shown in Table (5). It could be indicated that the positive control group has the highest significant in all parameters of lipid profile except HDL-C. Groups as anti-obesity have significant (P <
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

0.05) increases in serum levels of TC, TG, LDL-c, VLDL-c, and atherogenic index when compared with the normal group. However, a significant decrease in TC, TG, LDL-c, VLDL-c, and atherogenic index levels was observed for the groups’ levels 3, 2 and 1ml of red radish juice when compared with a positive control group. The more prominent effect is observed in LDL-c which is a known triggering factor for coronary occlusion or its block. This can substantiate the cardio protective effect of red radish. This finding agrees with an earlier study by Tamura et al., (2010) who reported that several isoflavone constituents in red radish. They are phytoestrogen, which parallel estradiol, affect the digestive system, prevent serotonin reuptake, and thus raise serotonin levels in redeeming clamps. Also, Goyeneche et al., (2015) reported that the red radish exhibited a marked reduction in the hepatic total cholesterol and triglyceride levels both in the presence and absence of dietary cholesterol; the reduction of triglyceride levels in the absence of dietary cholesterol was in a dose-dependent manner. Red radish contains fibers, an effect of reducing the percentage of lipids. Red radish contains powerful antioxidant compounds that protect against chronic diseases (Islam et al., 2013). It may protect LDL cholesterol from oxidation, block cyclooxygenase and lipid enzymes and prevent lipid peroxide. It contains a high percentage of potassium, which helps to regulate blood pressure in the body (Giordano et al., 2007, and Haque et al., 2014).

CONCLUSION

In conclusion according to the obtained results, it seems that red radish roots juice could induce inhibitory effects on inflammatory cytokines such as TNF-α, and leptin in addition to resist in level. It also can improve the lipid profile, control and the total antioxidant capacity with relieving of the oxidative stress. Therefore, the consumption of red radish roots could be
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima A.F.E Ghozy and Rehab Ibrahim Tag Al Deen

beneficial for the control of adipose tissue-associated complications.

REFERENCES

Allain CC (1974):

Anna C; Capus A; Monnerat M; Ribeiro LC; de Souza W and Martins JL(2016):

Benzie IFF and Strain JJ (1999):
Ferric reducing/antioxidant power assay: Direct measure of total antioxidant activity of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. Methods Enzymol. 299, 15–27. 54.

Beopoulos A; Chardot T and Nicaud JM (2009):
Yarrowia lipolytica: a model and a tool to understand the mechanisms implicated in lipid accumulation. Biochimie 91: 692-696.

Beutler B; Greenwald D and Hulmes JD (1985):

Burstein M; scholnick HR and Morfin R (1970):
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

Cao G; Alessio H and Cutler R (1993):

Chapman DG; Castilla R and Campbell JA (1959):

Cheon CJ and Kim SY (2014):

Ferreira ES; Silva MA; Demonte A and Neves VA (2011):

Flohe L and Gunzler WA (1984):

Fossati P and Prencipe L (1982):

Friedewald WT; Levy RI and Frerickson DS (1972):

Ghiselli A; Serafini M; Maiani G; Azzini E and Ferro-Luzzi AA (1995):
Fluorescence-based method for measuring total plasma...
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima A.F. E Ghozy and Rehab Ibrahim Tag Al Deen


Golay A; Ferrara J; Felber J and Schneider H (1990):


Goyeneche R; Roua S; Ponce A; Vega-Gálvez A; Quispe-Fuentes I; Uribe E and Di Scala K (2015):

Gutiérrez RM and Perez RL (2017):

Gyamfi K; Sarfo DK; Nyarko BJ B; Akaho EK; Serfor-Armah Y and Ampomah-Amoako E (2011):
Assessment of elemental content in the fruit of Graviola plant, Annona Muricata, from some selected communities in Ghana by instrumental neutron activation analysis. Food Science. Elixir Food Science 41 5671-5675.

Haque M; Islam J; Rahaman A; Selina FA; Rahman MA; Hasan M and Hossain S (2014):
Raphanus sativus ameliorates atherogenic lipid profiles in
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima F.A.E Ghozy and Rehab Ibrahim Tag Al Deen


Levine LH; Bisbee PA; Richards JT; Birmele MN; Prior RL; Perchonok M; Dixon M; Yorio NC; Stutte GW and Wheeler RM (2010): Quality characteristics of the radish grown under reduced atmospheric pressure, Advances in Space Research, 41, 754–762.

Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

Liu KJ; Tso P; Xiong Y and Wang G (2010):
Antioesity and antihyperglycemic effects of ginsenoside Rb1 in rats. Diabetes. 59:2505-12.

Acylated anthocyanins from red radish (Raphanus sativus L.). Phytochemistry 60: 79-87.

Pellegrini N; Serafini M; Colombi B; Del-Rio D; Salvatore S; Bianchi M and Brighenti F (2003):
Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different in vitro assays. J. Nutr. 133, 2812–2819.

Pu Jing, Li-Hua Song, Shan-Qi Shen, Shu-Juan Zhao, Jie Pang, Bing-Jun Qian. (2014):

Reeves PG; Nielsen FH and Fahey GCJ (1993):

Goyeneche R (2015):

Vivarelli F; Canistro D; Sapone A; De Nicola GR; Babot Marquillas C; Iori R; Antonazzo IC; Gentilini F; and Paolini M (2016):
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shima F.A.E Ghozy and Rehab Ibrahim Tag Al Deen


Singleton CL; and Rossi JA (1965):
Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Viticult. 16, 144–158.
Molecules 2012, 17 10321 52.

Snedecor GW and Cochran WG (1967):

Tamura S; Tsuji K; Yongzhen P; Ohnishi - Kameyama M and Murakami N (2010):
Six new acylated anthocyanins from red radish (Raphanus sativus). Chem


Thorell JI (1973):

Yu L; Perret J; Harris M; Wilson J and Haley S (2013):
Antioxidant properties of bran extracts from “Akron” wheat grown at different locations. Journal of Agriculture and Food Chemistry, 51, 1566-1570

Yudkin JS (2003):

Zhao H L; Harding SV; Marinangeli CP; Kim YS and Jones PJ (2008):


Table 1: Antioxidant activity of fresh red radish juice from roots

<table>
<thead>
<tr>
<th>Antioxidant assay</th>
<th>FRAP (µmol Fe++/g)</th>
<th>TRAP (µmol TE/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red radish</td>
<td>1354.05</td>
<td>732.20</td>
</tr>
</tbody>
</table>

FRAP: Ferric reducing antioxidant  TRAP: total radical-trapping antioxidant

Table 2: Phenolic standards and their correlation with the compounds of red radish juice

<table>
<thead>
<tr>
<th>phenolic compound</th>
<th>RT /min</th>
<th>λ.max/nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallic acid</td>
<td>7.2</td>
<td>12.96</td>
</tr>
<tr>
<td>Pyrogallol</td>
<td>8.3</td>
<td>51.47</td>
</tr>
<tr>
<td>Coumaric</td>
<td>15.3</td>
<td>7.99</td>
</tr>
<tr>
<td>Catechin</td>
<td>18.9</td>
<td>47.11</td>
</tr>
<tr>
<td>Caffeine</td>
<td>14.5</td>
<td>71.21</td>
</tr>
<tr>
<td>Caffeic acid</td>
<td>19.3</td>
<td>320.20</td>
</tr>
<tr>
<td>Vanillic acid</td>
<td>20.1</td>
<td>208.16</td>
</tr>
<tr>
<td>Protocatechuic acid</td>
<td>21.3</td>
<td>77.11</td>
</tr>
</tbody>
</table>

(Rt/min): Retention times  (λ.max/nm): Maximum absorption
**Table (3): Effect of different levels of red radish juice on body weight gain, feed intake, FER, and BMI of the experimental rats’ groups**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control Group</th>
<th>Positive group</th>
<th>Anti-obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group 3</td>
</tr>
<tr>
<td>Feed intake (g/d)</td>
<td>17.33± 1.21a</td>
<td>16.55± 1.18a</td>
<td>16.10± 1.61b</td>
</tr>
<tr>
<td>Body weight gain (g)</td>
<td>90.87± 8.62a</td>
<td>130.62± 5.11d</td>
<td>98.44± 6.61b</td>
</tr>
<tr>
<td>FER</td>
<td>0.089± 0.008a</td>
<td>0.099± 0.006d</td>
<td>0.085± 0.004b</td>
</tr>
<tr>
<td>BMI (gm)/(cm)²</td>
<td>0.37</td>
<td>0.58</td>
<td>0.43</td>
</tr>
</tbody>
</table>

The values are expressed as mean ± SEM (n= 6 rats). Average values in every row holding unlike superscript (a, b, c) noted significant variation. Means with the same letter are insignificantly different.
Table (4): Effect of different levels of red radish juice on serum leptin, adiponectin, TNF-α, total antioxidant capacity and total oxidant capacity of the experimental rats’ groups

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control Group</th>
<th>Positive Group</th>
<th>Group 3 (1ml)</th>
<th>Group 4 (2 ml)</th>
<th>Group 5 (3 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptin (pg/ml)</td>
<td>2.83± 0.1c</td>
<td>7.98± 0.31a</td>
<td>5.63± 0.066a</td>
<td>4.05± 0.11b</td>
<td>3.65± 0.11b</td>
</tr>
<tr>
<td>Adiponectin (u/mL)</td>
<td>8.67± 0.06 a</td>
<td>4.98± 0.05 d</td>
<td>5.45± 0.04b</td>
<td>7.01± 0.47a</td>
<td>7.99± 0.47a</td>
</tr>
<tr>
<td>TNF-α (pg/ml)</td>
<td>3.18± 0.1d</td>
<td>8.73± 0.17 a</td>
<td>6.71± 0.126 b</td>
<td>4.36± 0.05bc</td>
<td>3.91± 0.05c</td>
</tr>
<tr>
<td>Total antioxidant capacity (mmol/L)</td>
<td>4.76± 0.04a</td>
<td>1.76± 0.04 d</td>
<td>2.94± 0.013c</td>
<td>3.16± 0.013b</td>
<td>4.04± 0.013a</td>
</tr>
<tr>
<td>Total oxidant capacity (mmol/L)</td>
<td>3.26± 0.012a</td>
<td>0.235± 0.01d</td>
<td>1.36± 0.014c</td>
<td>2.57± 0.01ab</td>
<td>2.89± 0.01a</td>
</tr>
</tbody>
</table>

The values are expressed as mean ± SEM (n= 6 rats). Average values in every row holding unlike superscript (a, b, c) noted significant variation. Means with the same letter are insignificantly different.
Table (5): Effect of different levels of red radish juice on serum lipid profile of the experimental rats’ groups

<table>
<thead>
<tr>
<th></th>
<th>Groups</th>
<th>Control group</th>
<th>Positive Group</th>
<th>Anti-obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Group 3 1ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Group</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parameters</td>
<td></td>
<td>1ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Group 3 1ml</td>
</tr>
<tr>
<td>TC</td>
<td>mg/dl</td>
<td>77.30 ± 3.66c</td>
<td>146.69 ± 4.98a</td>
<td>110.28 ± 4.45b</td>
</tr>
<tr>
<td>TG</td>
<td>mg/dl</td>
<td>81.84 ± 3.65c</td>
<td>156.51 ± 3.69a</td>
<td>98.44 ± 6.61 b</td>
</tr>
<tr>
<td>HDL-C</td>
<td>mg/dl</td>
<td>41.75 ± 1.13a</td>
<td>31.48 ± 1.87c</td>
<td>37.92 ± 2.11 b</td>
</tr>
<tr>
<td>LDL-C</td>
<td>mg/dl</td>
<td>28.59 ± 3.23c</td>
<td>49.89 ± 5.67a</td>
<td>39.88 ± 3.01 b</td>
</tr>
<tr>
<td>VLDL-C</td>
<td></td>
<td>12.84 ± 0.23c</td>
<td>22.39 ± 0.13a</td>
<td>17.86 ± 0.24b</td>
</tr>
<tr>
<td>AI</td>
<td></td>
<td>2.00</td>
<td>4.00</td>
<td>3.51</td>
</tr>
</tbody>
</table>

The values are expressed as mean ± SEM (n= 6 rats).
Average values in every row holding unlike superscript (a, b, c) noted significant variation. Means with the same letter are insignificantly different.

TC: Total Cholesterol
TG: Triglycerides
HDL-c: High density lipoprotein
LDL-c: Low density lipoprotein
VLDL-c: Very low-density lipoprotein
AI: Atherogenic Index
Effect of Fresh Red radish Roots Juice on some Biomarker for hypertrophy of adipose tissue in Obese Rats

Shimaa F.A.E Ghozy and Rehab Ibrahim Tag Al Deen

Bulletin of the National Nutrition Institute of the Arab Republic of Egypt. December 2019 (54) 20