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Jerusalem artichoke tubers, Onion and Hulless barley as Functional Foods in Alloxan Induced Diabetic Rats

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ABSTRACT

The present study aimed to evaluate the biochemical parameter of diabetic rats fed on some functional foods (Jerusalem artichoke tuber, Onion and Hulless barley). Insulin hormone, glucose level, total cholesterol and triglycerides in diabetic rat serum were estimated. The obtained results indicated that the diets fortified with Jerusalem artichoke tuber powder (JAT), Onion and Hulless barley induced a significant decrease in serum glucose levels for all groups when comparing with the positive control. Pronounced decrease occurred in serum glucose levels, total cholesterol and triglycerides in contrast to increasing insulin hormone in the hyperglycemic rats during feeding on different diets of functional foods comparing to the positive control. Evident decrease occurred in serum total cholesterol and triglycerides of rats fed on different diets of functional foods comparing to the positive control. Thus, diet containing different resources of functional foods could reduce serum glucose levels, triglycerides and total cholesterol in the hyperglycemic rats.

Key words: Functional foods, Jerusalem artichoke tuber (JAT), Onion, Hulls Barley, Diabetic, Hyperglycemic, insulin hormone and Cholesterol.

Introduction

Diabetes mellitus is a complex disorder. It is characterized by hyperglycemia, often with hypertriglyceridemia (chylomicrons and VLDL) resulting from malfunction in insulin secretion and/or insulin action both causing by impaired metabolism of glucose, lipids and protein as reported by Scheen (1997).

Many herbs have remained as an alternative to conventional therapy especially in poor areas where commercial insulin is not readily available.

Considerable interest has been generated in Jerusalem artichoke tubers(JAT) (Helianthus tuberosus L.), mainly because this crop is an excellent source of both soluble and insoluble fibers. Fructo-oligosaccharides(FOS), the soluble fibers components have been identified as an important substrate for desirable intestinal flora, especially bifidobacteria as recorded by Roberfroid et al. (1998) and El-Hofi (2005). Also used for prevention of cancer as recorded by Slavin (1977).

In general, soluble fibers decrease serum cholesterol and low density lipoprotein (LDL) cholesterol without affecting serum triglycerides. Often consumption of these soluble fibers is accompanied by distinct reductions in serum high density lipoprotein (HDL) cholesterol concentrations. Soluble fibers such as inulin which found in a number of mono and dicotyledonous families such as Onion, Jerusalem artichoke and barley appear to exert their principal effects on cholesterol metabolism through a decrease in bile acid absorption in the small intestine according to Anderson and Hanna (1999).

Jerusalem artichoke tubers (JAT) helps in maintain blood sugar level in the human at normal level. The effect of JAT as reported by Alegria and Vivanco (2004) is due to optimum quantity of the polysaccharide inulin, potentially useful for diabetics.

Inulin is a plant-derived carbohydrate with the benefits of soluble dietary fibers which are not digested or absorbed in the small intestine, but fermented in the colon by beneficial bacteria. Functioning as a prebioticinulin has been associated with enhancing the gastrointestinal system and immunity system. In addition, it has been shown that it increases the absorption of calcium and magnesium, influences of blood glucose and reduces serum level of cholesterol, serum lipoproteins as reported by Coudry et al. (1997) and Niness (1999).

Kaur and Gupta (2002) and Daubioul et al. (2005) indicated that inulin-type fructans such as oligofructose (OFS) in the diet decreased triacylglycerol accumulation in the liver tissue and decreased significantly serum aminotransferase and aspartate aminotransferase after 3 weeks in the serum of diabetic rats.

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Allium species such as Onion used as foodstuff, condiment, flavoring, and folk medicine. Onion has attracted particular attention of modern medicine because of its wide spread health use around the world, and the cherished belief that it helps in maintaining good health, ward off illnesses and providing more vigor.

A variety of sulfur-containing compounds and their precursors are the main compounds, which attribute to the antioxidant activity of Allium plants (Nuutila et al., 2003). In addition to sulfur-containing compounds, Onion has a large amount of quercetin, which has antioxidant effects (Jung et al., 2002).

Dickin et al., (2010) reported that, utilization of barley, as a human food is potentially a missed opportunity for public health as components of barley grain, especially β-glucan soluble fiber, have the proven ability to ameliorate diet-related health problems, including obesity, type-2 diabetes and high cholesterol.

Materials And Methods

Food Materials: Jerusalem artichoke tubers (JAT) and Onion were purchased from the Faculty of Agriculture, Ain Shams University, washed and sliced individually to thickness of approximately 1 mm. Thereafter were subjected to dryness at 60-70 ± 5o C, beside Hulless barley blended, packed and kept in deep freezer. Hulless barely grains provided from Agriculture Research Center at El-Giza, Egypt.

Animals: Twenty five male albino rats each weighing (150-155 gm), were allowed to be acclimatized to laboratory conditions for one week prior to the experiment and fed on basal diet as control.

Induction of diabetes:

Animals were fasted for 48 hours and then a single intra-peritoneal injection (IP) of freshly prepared saline (containing 120 mg of recrystallized Alloxan monohydrate /1000 gram of body weight) given through its intra-peritoneal according to Ji Su Kim et al., (2006).

Treatment with Functional Foot:

Rats were fed on basal diet for 72 h during which hyperglycemia was developed. To ensure occurrence of diabetes in rats, blood samples were withdrawn 72 h after alloxan injection. The diabetic rats were divided into five groups(Control, Diabetes, JAT, Onion and Hulless Barley), 5 rats each. Each group was fed on experimental diet shown in Table (2). During the whole experiment period, diet and water were supplied ad-lib.

Every week, animals were fasted over night; blood samples were collected in test tubes from each rat and centrifuged at 3000 rpm for 20 min. The serum was kept frozen at (-20°C) until analysis.

Application induces rat “chemical diabetes” by damaging the insulin secreting pancreatic β-cell, resulting in a decrease in endogenous insulin release as mentioned by Lenzen and Panten, (1988) in there study on Alloxan mechanism of action and Oberley (1988) in his study on Alloxan mode of action.

Biochemical analysis of serum:

- Blood glucose was estimated by the method of Sivanathan and Sankaranarayanan (2007). The popularly Glucose Oxidation based on the following reactions:

  \[ \text{Glucose} + \text{glucose oxidation} \rightarrow \text{gluconic acid} + \text{H}_2\text{O}_2 \]

  \[ 2 \text{H}_2\text{O}_2 + \text{phenol} + \text{amino – 4 - antipyrine} \xrightarrow{\text{peroxides}} \text{Quinone imine} + 4 \text{H}_2\text{O} \]

- Insulin activity determined by the method adopted by Sapin (2003), using kits cobs: Sandwich principle: Total duration of assay = 18 minutes.

- Triglycerides were determined calorimetricusing wavelength of 365 nm by the method of Bucolo and David (1973).

  \[ \Delta E = \Delta E \text{ sample} - \Delta E \text{ blank} \]

  \[ \text{Triglyceride mg/dL} = \Delta E \times 1076. \]

  Where \( \Delta E \text{ sample} \) = extinction of sample

  \( \Delta E \text{ blank} \) = extinction of blank

- Cholesterol was analyzed calorimetric at wave length 560 nm, the amount of cholesterol was determined according to the following equation by the method of Wybenga et al.(1970).

  \[ \text{mg cholesterol/100ml/serum} = \frac{\text{Reading of sample}}{\text{Reading of standard}} \times 0.05 \]
Statistical Analysis: All values are presented as means ± SE. A mixed models procedure for one way analysis of variance. Where a significant difference was indicated, the Tukey test was used to determine significant differences between groups. \( P \leq 0.05 \) was considered to be statistically significant according to SAS (2006).

Table 1: Chemical composition of Jerusalem artichoke tubers, Onion tubers and Hulless barley grains

<table>
<thead>
<tr>
<th>Constituents *%</th>
<th>Jerusalem artichoke tuber</th>
<th>Onion</th>
<th>Hulless barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>2.40 ± 0.05</td>
<td>4.60 ± 0.05</td>
<td>2.2 ± 0.05</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>85.00 ± 0.57</td>
<td>74.20 ± 0.14</td>
<td>65.3 ± 0.88</td>
</tr>
<tr>
<td>Crude protein</td>
<td>7.45 ± 0.14</td>
<td>10.60 ± 0.12</td>
<td>13.0 ± 0.57</td>
</tr>
<tr>
<td>Crude fibers</td>
<td>1.28 ± 0.05</td>
<td>6.40 ± 0.08</td>
<td>13.0 ± 0.57</td>
</tr>
<tr>
<td>Ash</td>
<td>2.00 ± 0.08</td>
<td>4.4 ± 0.06</td>
<td>3.5 ± 0.05</td>
</tr>
<tr>
<td>Fats</td>
<td>1.00 ± 0.05</td>
<td>0.8 ± 0.05</td>
<td>3.0 ± 0.21</td>
</tr>
</tbody>
</table>

* Percentage calculated on dry weight basis
* Each value = the average of three determination ± standard error

Table 2: basal diet composition

| 20% | casein |
| 15% | sunflower seed oil |
| 5%  | salt mixture |
| 5%  | vitamins |
| 55% | corn starch |

Table 3: Diet constituent of the experimental groups

<table>
<thead>
<tr>
<th>Component of the diet g.</th>
<th>Diet I %</th>
<th>Diet II %</th>
<th>Diet III %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jerusalem artichoke tuber</td>
<td>Onion group</td>
<td>Hulless barley group</td>
</tr>
<tr>
<td>Casein (1)</td>
<td>14.0</td>
<td>12.0</td>
<td>11.25</td>
</tr>
<tr>
<td>Sunflower seed oil</td>
<td>15</td>
<td>13.0</td>
<td>13.5</td>
</tr>
<tr>
<td>Salt mixture (1)</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Vitaminized starch (1)</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Carbohydrate (1)</td>
<td>61.0</td>
<td>65.0</td>
<td>65.75</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The difference in each diet composition, depending upon the composition of the material used in-groups, comparing with the basal diet.

Results And Discussion

Biochemical analysis:

Effect of functional foods on Serum insulin and glucose levels:

Data of serum insulin level in diabetic and functional food treatment rats during the investigation period are listed in table (4).

Table 4: Effect of Jerusalem artichoke, Onion and barley on serum insulin level in diabetic male albino rats during 30 days

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Serum insulin (µU/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control non-diabetic</td>
</tr>
<tr>
<td>0</td>
<td>10.60 ± 0.07 *</td>
</tr>
<tr>
<td>7</td>
<td>10.12 ± 0.14 *</td>
</tr>
<tr>
<td>14</td>
<td>10.50 ± 0.08 *</td>
</tr>
<tr>
<td>21</td>
<td>10.80 ± 0.07 *</td>
</tr>
<tr>
<td>30</td>
<td>10.70 ± 0.08 *</td>
</tr>
</tbody>
</table>

Means with the same letter in rows are not significantly different at \( P<0.05 \) significance level.

Data of serum insulin in rats under investigation in Table listed (4) revealed that, serum insulin content in all treatments around 10.50 µU/ ml at zero time. After 7 days (Alloxan-induced diabetic rats), the level of serum insulin in non- diabetic rats (control –ve group) still around the same value 10.12 µU/ ml, while the serum insulin level in diabetic rats (control +ve group) decreased to 2.7± 0.19µU/ml.

Data illustrate that, insulin level still constant in all diabetic treatments (at 7 days in addition to diabetic control to the end of the experiment). On the other hand, serum insulin level in the other treatments (Jerusalem artichoke (JA), Onion and Hulless barley) at 7 days = 2.5 ± 0.04, 2.5 ± 0.14 and 2.3 ± 0.19 µU/ml respectively. The same trend with a slight increment could be observed at 14 days, where the non-diabetic rats (control –ve group) = 10.5 ± 0.08 µU/ml, the diabetic rats (control +ve group) = 2.6 ± 0.10 µU/ml, in addition to 6.6 ± 0.08,
6.4 ± 0.08and 6.3 ± 0.10 µU/ml for Jerusalem artichoke (JA), Onion and Hulless barley respectively. There is more slight increment after 21 days long, where serum insulin in the non-diabetic rats (control –ve group) = 10.8 ± 0.07 µU/ml, diabetic rats (control +ve group) = 2.2 ± 0.10µU/ml and the other three treatments 8.6 ± 0.07, 8.2± 0.07and 7.9 ± 0.10 µU/ml respectively.

After 30 days, the level of serum insulin in the non-diabetic rats (control –ve group) = 10.7 ± 0.08µU/ml, diabetic rats (control +ve group) = 2.96 ± 0.11µU/ml, the other treated groups at the same time = 9.9 ± 0.08, 9.9 ± 0.08 and 9.0 ± 0.11 µU/ml respectively.

Data showed significant decreases of serum insulin for all groups (diabetic rats) fed on Jerusalem artichoke, Onion and barley compared with the control positive one.

Jerusalem artichoke is not a source of insulin. The content carbohydrate is inulin. Insulin is a protein (hormone) that controls glucose absorption by animal cells. If eaten, insulin is broken down to its component, which is why insulin injected.

Insulin is a carbohydrate breaks down to fructose. Fructose not used to treat diabetes, but considered a better sugar for most diabetics because it converted to glucose before being absorbed by cells

Results are in agreement with Rumessen (1990) in their study on the influence of Fructans isolated from Jerusalem artichoke on blood glucose, insulin, and C-peptide responses. Also Yamashita et al., (1984), when they concluded that, Neo-sugar lowered blood glucose concentration in non-insulin-dependent diabetic.

Experimental and clinical evidence suggests that Onion contains an active ingredient called APDS (allyl propyl disulphide). APDS blocks the breakdown of insulin by the liver and possibly stimulates insulin production by the pancreas, thus increasing the amount of insulin and reducing sugar levels in the blood.

Ji Younger et al., (2011) stated that, Onion is a good source of mineral chromium, needed for glucose metabolism and insulin sensitivity. Onion can fulfill 20 percent of daily chromium requirement, and Figure it against diabetes. Hypoglycemic and insulin-sensitizing capability demonstrated by significant improvement of glucose tolerance. The insulin-sensitizing/effect, supported by increasing glycogen levels in peripheral tissues, like liver and skeletal muscle. The oxidative stress, as assessed by superoxide dismutase activity and malondialdehyde formation, plasma free fatty acids, and hepatic protein expressions reduced significantly.

Data of Onion is in agreement with Ji Young et al., (2011) when they concluded that, Onion peel extract improve glucose response and insulin resistance associated with type 2 diabetes by alleviating metabolic deregulation of free fatty acids, suppressing oxidative stress, up-regulating glucose uptake at peripheral tissues, and/or down-regulating inflammatory gene expression in liver.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Serum glucose level (mg/dL)</th>
<th>Time/days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Control diabetic</td>
<td>Jerusalem artichoke</td>
</tr>
<tr>
<td>0</td>
<td>98.2 ± 0.38°</td>
<td>98.6 ± 0.49°</td>
</tr>
<tr>
<td>7</td>
<td>98.0 ± 0.62°</td>
<td>325.3 ± 0.80°</td>
</tr>
<tr>
<td>14</td>
<td>98.0 ± 0.62°</td>
<td>324.6 ± 0.80°</td>
</tr>
<tr>
<td>21</td>
<td>98.6 ± 0.69°</td>
<td>325.6 ± 0.90°</td>
</tr>
<tr>
<td>30</td>
<td>98.3 ± 0.39°</td>
<td>325.6 ± 0.50°</td>
</tr>
</tbody>
</table>

Means with the same letter in rows are not significantly different at P< 0.05 significance level

Data in Table (5) illustrate, that the serum glucose level increment (control diabetic, Jerusalem artichoke, Onion and Hulless barley) at 7 days, due to Alloxan treatment. On the other hand, it is clear from the results at 14, 17 and 30 days that, serum glucose level decreased by 23 - 25%, when rats fed Jerusalem artichoke (JA), Onion or Hulless barley respectively comparing with control diabetic rats.

These observations may be due to the dietary fibers (Fructo-oligosaccharides, FOS) as suggested by Kopec and Cieslik (2005) in their study on Jerusalem artichoke tubers as a source of both soluble and insoluble fibers. They concluded that the soluble fibers components identified as a substrate for desirable intestinal flora, especially bifido bacteria.

In addition, Mi-Ae Bang et al., (2009) in their study to illustrate the anti-diabetic effect of Onion (Allium cepa. Linn) they stated that, Onion decreased the total serum lipid, triglyceride and increased HDL-cholesterol/total cholesterol ratio in the diabetic rats. Glutathione peroxidase, glutathione reductase and glutathione S-transferase activities were high in the diabetic rats compared to normal rats and reverted to near-control values by Onion. Their results indicated that Onion decreased blood glucose, serum lipid levels and reduced renal oxidative stress in STZ-induced diabetic rats and this effect might exert the anti-diabetic effect of Onion.

Onion (Allium cepa. Linn), commonly used in our daily diet, has been extensively studied for its therapeutic uses (Reddy et al., 1993). Aqueous extraction of Onion showed an antithrombotic effect in streptozotocin (STZ)-induced diabetic rats (Jung et al., 2002). However, there is a little information about the effect of Onion on the complication of diabetes.
It may promote bifidobacteria in colonic microflora and does not rise in colonic microflora and blood glucose or insulin upon ingestion according to Rumessen et al., (1990).

**Table 6:** Effect of Jerusalem artichoke, Onion and Hulless barley on Serum Total Cholesterol (mg/dL) in diabetic male albino rats during 30 days

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control non-diabetic</th>
<th>Control diabetic</th>
<th>Jerusalem artichoke</th>
<th>Onion</th>
<th>Hulless barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>95.4 ± 2.00*</td>
<td>96.3 ± 2.58*</td>
<td>97.2 ± 2.00*</td>
<td>99.2 ± 2.00*</td>
<td>93.6 ± 2.58*</td>
</tr>
<tr>
<td>7</td>
<td>93.8 ± 2.66*</td>
<td>185.6 ± 3.44*</td>
<td>186.0 ± 2.66*</td>
<td>177.6 ± 2.60*</td>
<td>173.4 ± 3.44*</td>
</tr>
<tr>
<td>14</td>
<td>99.2 ± 1.30*</td>
<td>185.6 ± 1.69*</td>
<td>146.6 ± 1.31*</td>
<td>141.8 ± 1.31*</td>
<td>146.0 ± 1.69*</td>
</tr>
<tr>
<td>21</td>
<td>93.6 ± 1.10*</td>
<td>179.0 ± 1.43*</td>
<td>103.8 ± 1.10*</td>
<td>109.4 ± 1.10*</td>
<td>105.4 ± 1.40*</td>
</tr>
<tr>
<td>30</td>
<td>90.8 ± 1.16*</td>
<td>184.8 ± 1.50*</td>
<td>97.4 ± 1.16*</td>
<td>98.4 ± 1.16*</td>
<td>95.8 ± 1.50*</td>
</tr>
</tbody>
</table>

Means with the same letter in rows are not significantly different at *P* < 0.05 significance level.

Data of serum total cholesterol in rats under investigation during 30 days long, listed in Table (6). At zero time, the level of total cholesterol in rats were around the normal values (non-diabetic control = 95.4 ± 2.0 mg/dL, diabetic control = 96.3 ± 2.58 mg/dL, Jerusalem artichoke = 97.2 ± 2.0 mg/dL, Onion = 99.2 ± 2.0 mg/dL and Hulless barley = 93.6 ± 2.58 mg/dL).

At 7 days (after injection of Alloxan), total cholesterol of non-diabetic control (control –ve group) still around the normal ones = 93.8 ± 2.66 mg/dL, while the other treatments increased values significantly, diabetic rats (control +ve group) = 185.6 ± 3.44 mg/dL (94.5% from zero time), Jerusalem artichoke = 186.0 ± 2.66 mg/dL (95.0% from zero time), Onion = 177.6 ± 2.6 mg/dL (86.0% from zero time) and Hulless barley = 173.4 ± 3.44 mg/dL (81.7% from zero time).

At 14 days, total cholesterol level in non-diabetic rats (control –ve group) = 99.2 ± 1.3 mg/dL, while the level of diabetic rats (control +ve group) increased value to 185.6 ± 1.69 mg/dL. On the other hand, the level of total cholesterol in treated rats with Jerusalem artichoke increased to 146.6 ± 1.31 mg/dL (53.6% from zero time and 47.7% from non-diabetic ones), Onion treatment increased to 141.8 ± 1.31 mg/dL (48.6% from zero time and 42.9% from non-diabetic ones) finally Hulless barley treatment increased to 146.0 ± 1.69 mg/dL (53.0% from zero time and 47.0% from non-diabetic ones) all at 14 days.

At 21 days, the total cholesterol level in non-diabetic rats (control –ve group) still around the normal values (93.6 ± 1.1 mg/dL), while the level of total cholesterol in diabetic rats (control +ve group) increased significantly to 179.0 ± 1.43 mg/dL (87.6% from zero time and 91.2% from non-diabetic ones).

On the other hand, total cholesterol level in treated groups by the used functional foods decreased values significantly comparing with diabetic control rats, where the level of total cholesterol in treated rats with Jerusalem artichoke recorded 103.8 ± 1.10 mg/dL (8.8% increment from zero time and 10.8% increment from non-diabetic control, accompanies with a decrement by 42.1% from diabetic control ones).

It could be remarked a same trend by Onion treatment, 109.4 ± 1.10 mg/dL, which means 14.6% increment from zero time and 16.8% increment from non-diabetic control, concomitant by a decrement by 38.9% from diabetic control ones, finally Hulless barley recorded 105.4 ± 1.40 mg/dL, which means 10.4% increment from zero time and 12.6% increment from non-diabetic control, accompanied by a decrement by 41.2% from diabetic control ones.

Same trend with Hulless barley feeding at 21 days, 105.4 ± 1.40 mg/dL, which means 10.4% increment from zero time, and 12.6% increment from non-diabetic control, accompanied by a decrement by 41.2, 3% from diabetic control ones at 21 days.

At 30 days, the total cholesterol level in non-diabetic rats (control –ve group) still around the normal values (90.8 ± 1.16 mg/dL), while the level of total cholesterol in diabetic rats (control +ve group) increased value significantly to 184.8 ± 1.50 mg/dL (93.7% from zero time and 103.5% from non-diabetic ones).

On the other hand, total cholesterol level in treated groups by the functional foods decreased significantly comparing with diabetic control rats, where the level of total cholesterol in treated rats with Jerusalem artichoke recorded 97.4 ± 1.16 mg/dL (around normal values comparing with zero time and 7.2% increment from non-diabetic control at 30 days, accompanies with a decrement by 47.3% from diabetic control one).

It could be remarked a same trend by Onion treatment, 98.4 ± 1.16 mg/dL (around control values) from zero time and 8.3% increment from non-diabetic control, concomitant by a decrement by 46.8% from diabetic control at 30 days, finally Hulless barley recorded 95.8 ± 1.50 mg/dL, which means normal value from zero time and 5.5% increment from non-diabetic control, accompanied by a decrement by 46, 8% from diabetic control at 30 days.
Same trend with Hulless barley feeding at 30 days, 95.8 ± 1.50 mg/dL, which means, the resulted value around control values from zero time, and 5.5% non-significant increment from non-diabetic control, accompanied by a decrement by 48.2% from diabetic control at 30 days.

Data in Table (6), showed significant decreases in serum total cholesterol for all groups (diabetic rats) fed on Jerusalem artichoke, Onion and barley compared with the control positive. The highest values of serum triglyceride content was in positive control, while the lowest one in group fed functional foods (Hulless barley, Onion and Jerusalem artichoke) respectively.

Results indicated that, Hulless barley, Onion and Jerusalem artichoke reduced cholesterol and triglyceride levels in diabetic rat serum.

The hypolipidimic effect of Jerusalem artichoke may be due to increasing fecal lipid excretion and decreasing lipid absorption, as reported by Cieslik et al., (2002) and Eid (2009). These results are in agreement with those reported by Andusan and Hanna (1999) and Eid (2009).

Chrapkowska et al., (1993) and Ewa Cie et al., (2005), reported that, total serum cholesterol level in rats fed diet containing Jerusalem artichoke flower supplement revealed a decreasing tendency, most probably propionic acid formed in result of fructan fermentation might have blocked cholesterol synthesis in liver through inactivation of β-hydroxy, β-methylglutarilo-CoA and lowered total cholesterol level. Moreover, pectin and hemicellulose present in Jerusalem artichoke tuber binding exogenous cholesterol in the small intestine. In addition, soluble fraction of dietary fiber might have bound bile acids in liver leading to decrement in their synthesis from cholesterol.

Varlamova et al., (1996) and Ewa Cie et al., (2005) in their nutritional experiment with rats found that, total cholesterol level was decreasing with growing proportions of Jerusalem artichoke flour supplement in diet.

Yamaguchi et al., (2000) obtained similar results in their experiment with rats in which they added a levan (branched fructan) to the experimental diets.

The anti-diabetic effect of Onion (Allium cepa. Linn) in the streptozotocin (STZ)-induced diabetic rats. Male Sprague-Dawley rats were divided into normal rats fed control diet or supplemented with Onion powder (7% w/w) and diabetic rats fed control diet or supplemented with Onion powder. Blood glucose levels of rats supplemented with Onion were lower than those of rats fed control diet in the diabetic rats. Onion also decreased the total serum lipid, triglyceride in the diabetic rats compared to normal rats and reverted to near-control values by Onion, as reported by Mi-Ae Bang et. al., (2009).

We observed Onion lowered serum lipids in the diabetic rats. The lowering effect on serum lipids in the diabetic rats might be associated with a good glucose control by Onion. A good glucose control was reported to improve the parameters of serum lipid profile in rats with diabetes mellitus (Medvedeva et al., 2002). Onion itself was also reported to have a serum lipid lowering effect in hyperlipidemic experimental animals (Carson 1987). Serum lipid lowering effect of Onion can be one of the mechanisms of anti-diabetic effects and contribute to the prevention of diabetic nephropathy. Hyperlipidemia is a risk factor for declining kidney function in patients with diabetic nephropathy (Bordia et al., 1975). It was also reported that patients with low serum cholesterol concentration exhibited a lower degree of kidney lesions than those with high serum cholesterol concentration (Mulec et al., 1990). Most of the diabetes-induced changes were reverted to near normal values by Onion in this study. The possibility that modulation of the hyperglycemic status by Onion contributed to the amelioration of renal lesions cannot be ruled out. Another possibility is that Onion itself acted as an antioxidant and could attribute to the amelioration of free radical induced toxicity in the diabetic kidneys. A variety of sulfur-containing compounds and their precursors are the main compounds, which attribute to the antioxidant activity of Allium plants (Nuuttila et al., 2003). In addition to sulfur-containing compounds, Onion has a large amount of quercetin, which has antioxidant effects (Jung et al., 2002). Therefore, we can conclude that oxidative stress was induced in the kidneys of diabetic animals and effectively prevented by Onion.

We compared the effects of Hulless barley β-glucans as an adjunct to normal, and diabetic rats. During 30 days long of supplementation with Hulless barley, small changes in blood lipids were found. The amounts of beta-glucan fed in this study were predicted to significantly lower serum cholesterol. The cholesterol-lowering activity of barley is thought to be due to the β-glucan in the fractions of soluble fiber found within these grains. The β-glucan found in barley. Assuming that β-glucan is the active hypocholesterolemic component, it is reasonable to expect soluble fiber from barley to have cholesterol-lowering capabilities.

Data was in agreement with that found by Behall et al., (2004) (2), in their study by adding barley to the diet. They found that barley reduced serum total and LDL-cholesterol. In addition Behall et al., (2004) (3) in their study of hypercholesterolemic men and women by consumption of barley products for 6 weeks, recorded a reduction in both serum total cholesterol and LDL-cholesterol, indicating that the source of the soluble fiber was not critical to reducing lipids. These subjects had significant reductions in serum total cholesterol and LDL-cholesterol, without significant changes in triacylglycerol.

The mechanism explaining fiber's effect on hunger and body weight is unclear. Foods containing dietary fiber tend to provide bulk to the diet (Burton-Freeman, 2000), without providing as many calories, fat and added sugar.
On the other hand, the benefits of barley foods may go beyond lowering cholesterol as reported by Pins and Kaur (2006). Results of some recent studies are especially relevant due to the rise in the prevalence of metabolic syndrome and prediabetes. Soluble fiber delayed glucose absorption in the gut and decreased postprandial blood glucose in healthy patients and diabetics.

Serum triglycerides:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control non-diabetic</th>
<th>Jerusalem artichoke</th>
<th>Onion</th>
<th>Hulless barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time/days</td>
<td>Serum Triglycerides (TG mg/dL)</td>
<td>Serum Triglycerides (TG mg/dL)</td>
<td>Serum Triglycerides (TG mg/dL)</td>
<td>Serum Triglycerides (TG mg/dL)</td>
</tr>
<tr>
<td>0</td>
<td>78.4 ± 1.97*</td>
<td>78.3 ± 2.55*</td>
<td>74.8 ± 1.97*</td>
<td>77.8 ± 1.97*</td>
</tr>
<tr>
<td>7</td>
<td>78.4 ± 2.18*</td>
<td>100.6 ± 2.82*</td>
<td>109.0 ± 2.18*</td>
<td>106.6 ± 2.18*</td>
</tr>
<tr>
<td>14</td>
<td>73.8 ± 1.43*</td>
<td>148.6 ± 1.85*</td>
<td>97.8 ± 1.43*</td>
<td>100.4 ± 1.43*</td>
</tr>
<tr>
<td>21</td>
<td>77.8 ± 1.77*</td>
<td>142.6 ± 2.28*</td>
<td>82.4 ± 1.77*</td>
<td>77.8 ± 1.77*</td>
</tr>
<tr>
<td>30</td>
<td>75.4 ± 1.52*</td>
<td>143.2 ± 1.96*</td>
<td>68.4 ± 1.52*</td>
<td>76.8 ± 1.52*</td>
</tr>
</tbody>
</table>

Means with the same letter in rows are not significantly different at P< 0.05 significance level.

Results of serum triglycerides in rats under investigation listed in Table (7). At zero time the levels of triglycerides of diabetic control, non-diabetic control, Jerusalem artichoke (JA), Onion and Hulless barley in rats were non-significantly different, they recorded 78.4 ± 1.97, 78.3 ± 2.55, 74.8 ± 1.97 and 71.6 ± 2.55 mg/dL respectively.

After 7 days (after injection of Alloxan) the level of triglycerides in the non-diabetic rats (control –ve group) still around the same value 78.4 ± 2.18 mg/dL, while the level of triglycerides in diabetic rats (control +ve group) at the same phase increased to 100.6 ± 2.82 mg/dL (22%) compared with control. On the other hand, the level of triglycerides in the other treated groups of Jerusalem artichoke (JA), Onion and Hulless barley, through the same period, were increased significantly = 109.0 ± 2.18 (29%), 106.6 ± 2.18 (27%) and 101.0 ± 2.82 mg/dL (22.4%) respectively.

After 14 days, triglycerides content in non-diabetic rats (control – ve group) decreased to the initial value 73.8 ± 1.43, while triglycerides content in the diabetic rats (control + ve group) at the same period increased significantly to 148.6 ± 1.85 mg/dL (47.3%) till the end of 30 days long. On the other hand, the levels of triglycerides in the treated rats (control +ve group) followed by Jerusalem artichoke (JA), Onion and Hulless barley through the same period have a slight increment = 97.8 ± 1.43, 100.4 ± 1.43 and 113.0 ± 1.85 mg/dL respectively.

After 21 days, the level of triglycerides in non-diabetic rats (control – ve group) still at the initial value 77.8 ± 1.77 mg/dL, while in the diabetic rats (control + ve group) at the same period increased significantly to 142.6 ± 2.28 mg/dL (45.1%). On the other hand, triglycerides content in treated groups by Jerusalem artichoke (JA), Onion and Hulless barley through the same period decreased to the normal values = 82.4 ± 1.77, 77.8 ± 1.77 and 86.0 ± 2.28 mg/dL respectively.

After 30 days, the level of triglyceride has the same trend as 21 days long where in the non-diabetic rats (control –ve group) = 77.8 ± 1.77 mg/dL, diabetic rats (control + ve group) = 143.2 ± 1.96 mg/dL, Jerusalem artichoke (JA) = 68.4 ± 1.52, Onion = 76.8 ± 1.52 and Hulless barley = 67.6 ± 1.96 mg/dL.

Data showed, significant decreases of serum triglycerides for all diabetic rats groups fed on Jerusalem artichoke, Onion and barley comparing with the control positive. It could be remarked the highest values of serum triglycerides in positive control, while the lowest value recorded in-group fed different functional foods (Hulless barley, Onion and Jerusalem artichoke), respectively.

The obtained data are in accordance with Ewa Cie et al., (2005) who reported that, the analysis of variance revealed a significant decrease in triglycerides concentration in rat blood serum fed diet containing 10%-15% Jerusalem artichoke flour.

A decline in blood serum triglycerides level affected by accelerated intestine peristalsis, which made difficult digestion and absorption of fats. In addition, hemicellulose and pectins present in Jerusalem artichoke tuber might bind bile acids and thus make difficult the process of emulsification, digestion and absorption of triglycerides. Moreover, fructans are fermented by bifidobacteria in the colon and the production of metabolism has short chain fatty acids, particularly propionic acid inhibit the enzymes of triglycerol synthetase, which makes difficult resynthesize of triglycerides. It also affects a decreased content of free fatty acids through intensifying insulin sensitivity, which influences decreased synthesis of triglycerides in the liver.

Results are in agreement with Ostrowska et al., (2001) when they concluded that, the consumption of brown Onions is effective in lowering plasma lipid levels and increasing clotting time in pigs. They added that, Onion diuretic and digestive properties, works against diabetes, it did not raise the fasting serum triglyceride level.
Concerning barley, Hugo et al., (2000) and Annica et al., (2004) stated that, barley is a good source of dietary, beta-glucan that has a number of human health benefits such as lower blood glucose responses and glycemic index, higher satiety ratings, cholesterol-lowering and anti-carcinogenic effects. Barley is potent inhibitor of cholesterogenesis.

Conclusion:

From the above-mentioned results, it could be concluded that the diet containing functional food such as Jerusalem artichoke tubers, Onion and Hulless barley reduced serum glucose levels, triglycerides and total cholesterol in the hyperglycemic rats.

References


