The hypolipidemic effect of *Portulaca oleracea* L. stem on hyperlipidemic Wister Albino rats

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**Abstract** *Portulaca oleracea* has been listed in the World Health Organization as one of the most used medicinal plants. *Portulaca oleracea* stems (POS) acts about 75% from weight of plant. The production of stems was the most economic between other organs. This study carried out to investigate the hypolipidemic effect of POS preparations. Three preparations of POS were tested: stem powder (POS-powder), stem infusion (POS-infusion) and stem 70% ethanolic extract (POS-ethanolic 70%). POS preparations contained useful components with different proportion such as polyphenolics, flavonoids, alkaloids, tannins, saponins and mucilage. The effect of POS on weight and lipid profile investigated on dietary hyperlipidemic Wister Albino rats fed on hyperlipidemic diet contained 20% fat, 1% cholesterol and 0.25% colic acid. The experimental period was 8-weeks. POS-powder form was supplemented at 10% in hyperlipidemic diet while POS-infusion and POS-ethanolic 70% force fed by 1.0 g/kg body weight. The hyperlipidemic model described with elevated weight, feed intake, total cholesterol (TC), total lipids (TL), triglycerides (TG), low density lipoprotein cholesterol (LDL-C), very low density lipoprotein cholesterol (VLDL-C) levels and risk ratio was significantly, compared with untreated control after 4 and 8 weeks. Contrary high density lipoprotein cholesterol (HDL-C) of hyperlipidemic control was decreased significantly. POS preparations improved all obvious abnormal lipid parameters and risk ratio compared with hyperlipidemic control. The abnormalities, which was shown on liver status of hyperlipidemic rats were ameliorated by administration of POS preparations significantly. Liver histology showed significant improvement after treating hyperlipidemic rats by POS form compared with hyperlipidemic control.

**Introduction**

*Portulaca oleracea* L. (subsp. oleracea) is a weed spread in the Egyptian fields has been used as a nutritious vegetable for human nutrition. *P. oleracea* has been mentioned in Egyptian texts from the time of the Pharaohs (Kesden and Will, 1987). It has been listed in the World Health Organization as one of the most used medicinal plants. The taste of plant is like spinach:
a slightly acidic and salty taste (Samy et al., 2004). In folk medicine, it has been used for remediation of dysentery, boils and sores, eczema, erysipelas, checking cough, dispelling phlegm and snake and insect-bite, diuretic, febrifuge, anti-septic, antispasmodic and vermifuge (Xaing et al., 2007). Also, many pharmacological effects of P. oleracea were documented like anti-oxidation, anti-bacteria, anti-virus, anti-ulcerogenic, anti-inflammatory, skeletal muscle-relaxant, wound-healing and hypoxic nerve tissue protective effect (Parry et al., 1993; Rashed et al., 2003; Xie, 2002; Wang et al., 2007). The seeds or its extracts; infusion, 70% alcoholic and petroleum ether have hypolipidemic and hypoglycemic activity in hyperlipidemic rats (El-Newary et al., 2011).

P. oleracea is a good source of compounds with a good human health benefits. These compounds include omega-3 fatty acids and β-carotene, vitamins and essential amino acids and glutathione (Liu et al., 2000; Simopoulos et al., 1992). It contains phenolics and alkaloids (Spina et al., 2008; Xaing et al., 2007). Flavonoids of P. oleracea L., contain Kaempferol, apigenin, myricetin, quercetin and luteolin as a major components (Xuqin et al., 2005).

The stem of P. oleracea (POS) acts about 75% from the weight of plant. It means that, stem was the biggest organs of plant and production of POS was economic. The production of stems was reached 22-25 and 2–2.7 ton/Fadden fresh and dry weight respectively. POS was very mucilaginous (El-Newary, 2012). Total fatty acid contents in POS ranged from 0.5 to 0.9 mg/g and α-linolenic is the major fatty acid followed by linoleic acid and palmitic acid Liu et al. (2000). However, the studies on the chemical and biological evaluation of POS stems were very little.

Hyperlipidemia is a heterogeneous disorder described by an elevation on total cholesterol (TC), triglycerides (TG), very low density lipoprotein cholesterol (VLDL-C), low-density lipoprotein cholesterol (LDL-C), free fatty acids (FFA), and apolipoprotein B (apo B) levels, as well as reduced high-density lipoprotein cholesterol (HDL-C) levels. These disorders were happened as results of metabolic disorders, or dietary and lifestyle habits (Kolovou et al., 2005). Several studies reveal that an increase in HDL-C and decrease in TC, LDL-C and TG are associated with a decrease in the risk of ischemic heart diseases. Many drugs have been reported as a hypolipidemic, including bile acid, resins, statins, fibrates, niacin and cholesterol absorption inhibitors are common treatments for hyperlipidemia. However, severe side effects are associated with the use of these drug for lipid-lowering medications (Rodenburg et al., 2004). Most of the anti-hyperlipidemic drugs are causing significant reduction in both TC and HDL-C (Saravanakumar et al., 2010). Many natural compounds were documented as a hypolipidemic agents such as polyphenolics, flavonoids, tannins, alkaloids, phytosterol, unsaturated fatty acids and dietary fibers. Many functional foods, including flaxseed, garlic, viscous fiber, almonds, nuts and soy proteins have been examined as hypolipidemic agents (Micallef and Garga, 2009). These functional foods are effective in reducing both TC, TG and LDL-C; and have no effect on HDL-C levels. Many medicinal plants were documented as a hypolipidemic agents: decreased TC, TG, LDL-C and increased HDL-C. These plants are Lycium barbarum polysaccharides (Ming et al., 2009), Flaxseed lignin (Fukumitsu et al., 2008 and Fukumitsu et al., 2010), Sesbania grandiflora (Saravanakumar et al., 2010), Adonis vernalis, (Lateef et al., 2012), purslane (P. oleracea L.) seeds (El-Newary, 2012) saffron (Meshmoul et al., 2013) and Cordia dichotoma pulp (Suliman and El-Newary, 2014).

The main target of this study was to evaluate the anti-hyperlipidemic and hepatoprotective effect of POS preparations against hyperlipidemic diet induced-hyperlipidemic rats. The protection effect of POS preparations was estimated by surveillance lipid profile (TL, TC, TG, LDL-C, VLDL-C and HDL-C) and liver functions (total protein, albumin, globulin, alanine aminotransferase and aspartate aminotransferase).

Material and methods

Plant material

Collection of plants

Cultivated P. oleracea subsp. oleracea (Riglah) was collected during summer 2014 from El-Sharkia Governorate, Egypt. Plants were identified by Dr. A. El-Megaly (Department of the herbarium of Flora and Phytotaxonomy Research, Horticulture Research Institute, Agriculture Research Center). The voucher specimen (No. 136) was deposited in the herbarium of (CAIM). Stems of plant were separated and air-dried at room temperature and completed drying on oven at 50 °C for 24 h.

Preparation of POS-infusion

Grinded dried POS (100 g) was steeped in liter boiling water and left over night at room temperature. Next, this infusion was decanted and centrifuged. The supernatant was dried by rotary evaporator and completed dryness on oven at 50 °C. The yield was 22.50 g/100 g dry stem (Afifi et al., 2005).

Preparation of POS-ethanolic 70%

POS powder (1000 g) was exhaustively extracted by cold maceration process with petroleum ether 40:60, chloroform, ethyl acetate and ethanol 70% sequentially according to Devi and Sharma (2004). The yield of ethanol 70% was 156.32 g/kg.

Chemical composition of POS preparations

• Crude fat% of Portulaca oleracea stems was determined according to the methods described by A.O.A.C. (2000).
• Unsaponifiable and saponifiable matter of Portulaca oleracea oil were separated and identified according to method of A.O.A.C. by GLC.
• The non-saponifiable matter was prepared according to A. O.A.C standard method No. 933/08.
• Fatty acid methyl esters of Portulaca oleracea stems oil were determined according to A.O.A.C standard method No. 969/33 (Firestone, 1990).

Phytochemical screening of POS preparations; POS-infusion and POS-ethanolic 70% were performed using standard procedures, which was described by Ballbaa et al. (1981). Total polyphenols were determined spectrophotometrically by Folin-Denis reagent as gallic acid according to Gorinstein et al. (2004). The total flavonoids and condensed tannins content were determined spectrophotometrically according to method of Lin and Tang (2007) and Julkunen-Titto (1985). Total saponins, total alkaloids and mucilage...
results of LD50, 1.00 g/kg (1/10 of effective dose) body weight. After adaptation period (7 days) animals were divided into five groups (each 6 rats). The first group fed on standard diet and force fed by normal saline solution to keep as untreated control. The second one fed on hyperlipidemic diet and force fed by normal saline solution to keep as hyperlipidemic control. The third one fed on hyperlipidemic diet supplemented with 10% POS-powder as HFD-POS-powder 10% group. The fourth and fifth groups fed on hyperlipidemic diet and force fed by POS-infusion or POS-ethanolic 70% at dose 1.00 g/kg/body weight/day as HFD-POS-infusion and HFD-POS-ethanolic 70% groups respectively. The rats were weighed every week, and food weighed daily even the end of experiment.

d) Samples: Blood samples were obtained from each of the eye venous plexuses by capillary tube at zero time (zero-day) and after 4-weeks. At the end of the experimental period (8-weeks) fasting rats, were sacrificed by ether and blood and organs were collected. Blood was centrifuged (4000g, 10 min, 4 °C by using Sigma labor centrifuge), and serum was separated. Livers were weighted freshly and kept in formalin 10% for patholog-
powder only contained sterol and/or terpenoids. POS\textsubscript{powder}, POS\textsubscript{infusion} contains mucilage. POS\textsubscript{powder}, POS\textsubscript{infusion} and POS\textsubscript{ethanolic 70\%} did not contain neither anthraquinones nor volatile oils. POS\textsubscript{powder} contains crude fiber about 24.11 ± 1.05\% (as insoluble dietary fiber).

Data in Fig.3 reported that, POS preparations contained polyphenolics and flavonoids, the high amount concentrated in POS\textsubscript{ethanolic 70\%}: 6.69\% and 1.16\%. Total alkaloids were present in all preparations of stems, while POS\textsubscript{infusion} contains highest amount: 11.68\%, compared with other preparations.
POS powder contains high amount of mucilage about 21.42%, while POS ethanolic 70% did not contain mucilage. Condensed tannins was present in POS preparations and POS infusion contains the highest content: 0.27%. Total saponins content occurred in POS preparations and the highest content showed in POS ethanolic 70%: 2.15%.

The hypolipidemic activity of POS preparations

Potential acute toxicity of POS preparations

Acute toxicity of POS infusion and POS ethanolic 70% was studied on mice after their orally administration, for 24 h. POS infusion or POS alcoholic 70% did record any mortality or any apparent symptoms toxicity during the first 24 h or after following 14 days under observation. The obtained results revealed that POS infusion and POS ethanolic 70% were safe up to 10 g/kg.

Table 1  Effect of Portulaca oleracea stems preparation on serum Glucose of hyperlipidemic rates.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Time of administration (weeks)</th>
<th>Treat mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-day</td>
<td>4-weeks</td>
</tr>
<tr>
<td>Untreated control</td>
<td>63.0 ± 1.0</td>
<td>65.9 ± 2.9</td>
</tr>
<tr>
<td>Hyperlipidemic control</td>
<td>63.7 ± 1.4</td>
<td>111.1 ± 1.9</td>
</tr>
<tr>
<td>HFD-POS powder 10%</td>
<td>61.9 ± 2.2</td>
<td>56.0 ± 4.7</td>
</tr>
<tr>
<td>HFD-POS Infusion</td>
<td>60.7 ± 0.5</td>
<td>75.1 ± 1.3</td>
</tr>
<tr>
<td>HFD-POS Ethanolic 70%</td>
<td>61.2 ± 3.3</td>
<td>94.3 ± 1.7</td>
</tr>
<tr>
<td>Time mean</td>
<td>62.1B</td>
<td>80.5B</td>
</tr>
<tr>
<td></td>
<td>Treatments</td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td>2.7</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Data in table were analyzed by two ways. 

$P \leq 0.05$, value with the same letter has no significant but value with different letter has significant at 0.05. 

Effect of POS on serum glucose

At zero time, there is no significant difference found among glucose of all groups. Feeding on hyperlipidemic diet elevated glucose level of hyperlipidemic control after 4-weeks (68.56%) (71.57%) and 8-weeks (68.56%), compared with untreated control.

At the zero time lipid profile of all groups was nearly equal, while feeding on hyperlipidemic diet for 4 and 8 weeks caused significant elevation on TL (87.19% and 85.35%), TG and VLDL-C (154.31% and 166.67%), TC (120.04% and 126.46%) and LDL-C (489.95% and 497.06%) of hyperlipidemic control rats with respect of each untreated control after 4 and 8 weeks respectively. In contrary administration of hyperlipidemic diet reduced HDL-C significantly after 4-weeks (31.62%) and after 8-weeks (36.18%) of hyperlipidemic control rats compared with each untreated control. Therefore risk ratio of rats was significantly magnified by about ten times in comparison with untreated control.

The POS treatments influence as shown in Tables 2 and 3 caused significant normalization on lipid profile compared with hyperlipidemic control. POS infusion was the most effective treatment on lipid profile of rats.

The time effect was appeared on lipid profile as significant increase on TL, TG and VLDL-C, and TC and LDL-C were associated with increasing the time period with respect to those values at zero time. TC, LDL-C and risk ratio were elevated remarkably after 4-weeks and then decreased after 8-weeks in comparison with those of zero time. TL, TG and VLDL-C were increased after 4-weeks and were continued to increase until 8-weeks. On the other hand HDL-C was decreased after 4-weeks and then was elevated again after 8-weeks, compared with HDL-C level at zero time.

The interaction between time period and POS treatments showed that, TG and VLDL-C were diminished by administration of POS preparations for 4 and 8-weeks significantly in comparison with each hyperlipidemic control (Table 2). TG and VLDL-C of all treated groups were nearly equaled after 4 and 8 weeks.

TL, TC and LDL-C were declined remarkably as a response for administration POS preparations during 4 and 8 weeks, compared with each hyperlipidemic control ($P \geq 0.05$). POS ethanolic 70% showed the most amelioration on TL, TC and LDL-C equivalent to respective value of 52.68%, 56.35% and 86.62% respectively after 4-weeks in the case of TL and after 8-weeks in the case of TC and LDL-C, compared with hyperlipidemic control (Table 2 and 3).

HDL-C was boosted by feeding on HFD-POS powder 10% or force fed by POS infusion or POS alcoholic 70% during 4 and 8 weeks in comparison with hyperlipidemic control. The influence of POS powder 10% was more pronounced effect on HDL-C (58.77%) followed by POS ethanolic 70% (50.50%) after 8-weeks, with respect to hyperlipidemic control (Table 3).
Table 2  Effect of *Portulaca oleracea* stems preparations on serum Total Lipids (TL), Triglycerides (TG) and Very low density lipoprotein (VLDL-C) of hyperlipidemic rates.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total lipids (TL)</th>
<th>Triglycerides (TG)</th>
<th>Very low density lipoprotein (VLDL-C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-day</td>
<td>4-weeks</td>
<td>8-weeks</td>
</tr>
<tr>
<td></td>
<td>0-day</td>
<td>4-weeks</td>
<td>8-weeks</td>
</tr>
<tr>
<td></td>
<td>U untreated control</td>
<td>308.7^hi^ ± 5.7</td>
<td>310.9^h^ ± 15.1</td>
</tr>
<tr>
<td></td>
<td>Hyperlipidemic control</td>
<td>311.7^h^ ± 9.6</td>
<td>581.9^db^ ± 14.9</td>
</tr>
<tr>
<td></td>
<td>HFD-POS-powder</td>
<td>305.1^hi^ ± 3.3</td>
<td>447.0^c^ ± 16.9</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HFD-POS-Infusion</td>
<td>313.3^h^ ± 7.0</td>
<td>292.5^ij^ ± 12.0</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time mean</td>
<td>309.5^C^</td>
<td>381.5^B^</td>
</tr>
<tr>
<td></td>
<td>LSD treatments</td>
<td>9.89</td>
<td>7.66</td>
</tr>
<tr>
<td></td>
<td>Treatments time</td>
<td>4.88</td>
<td>3.78</td>
</tr>
<tr>
<td></td>
<td>Interaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LSD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data in table were analyzed by two ways.

*P* ≤ 0.05, value with the same letter has no significant but value with different letter has significant at 0.05.

Table 3  Effect of *Portulaca oleracea* stems preparations on serum total cholesterol (TC), Low density lipoprotein (LDL-C) and High density lipoprotein (HDL-C) of hyperlipidemic rates.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total Cholesterol (TC)</th>
<th>Low density lipoprotein (LDL-C)</th>
<th>High density lipoprotein (HDL-C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-day</td>
<td>4-weeks</td>
<td>8-weeks</td>
</tr>
<tr>
<td></td>
<td>0-day</td>
<td>4-weeks</td>
<td>8-weeks</td>
</tr>
<tr>
<td></td>
<td>U untreated control</td>
<td>60.1^f^ ± 1.9</td>
<td>70.4^e^ ± 7.7</td>
</tr>
<tr>
<td></td>
<td>Hyperlipidemic control</td>
<td>61.9^f^ ± 2.4</td>
<td>135.9^ab^ ± 13.2</td>
</tr>
<tr>
<td></td>
<td>HFD-POS-powder</td>
<td>61.1^f^ ± 3.8</td>
<td>132.5^b^ ± 5.4</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td></td>
<td>102.1^b^ ± 2.8</td>
</tr>
<tr>
<td></td>
<td>HFD-POS-infusion</td>
<td>59.7^f^ ± 3.2</td>
<td>111.5^d^ ± 9.9</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td></td>
<td>82.5^d^ ± 17.4</td>
</tr>
<tr>
<td></td>
<td>Time mean</td>
<td>60.8^C^</td>
<td>125.0^A^</td>
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<tr>
<td></td>
<td>LSD treatments time</td>
<td>3.43</td>
<td>2.66</td>
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<tr>
<td></td>
<td>Interaction</td>
<td></td>
<td>3.11</td>
</tr>
</tbody>
</table>

Data in table were analyzed by two ways.

*P* ≤ 0.05, value with the same letter has no significant but value with different letter has significant at 0.05.
Risk ratio (LDL-C/HDL-C) was decreased significantly as a response for treating by POS preparations for 8-weeks, with respect to hyperlipidemic control as Fig. 4. POS-ethanolic 70% recorded the highest decrease in risk ratio (90.08%) followed by POS-infusion (84.86%) after 8-weeks, ($P \geq 0.05$). Treatments showed significant influence in risk ratio and HFD-POS-infusion group showed the lowest risk ratio values between other groups treated with POS preparations with respect to hyperlipidemic control. Time period showed the same significant influence on risk ratio. The risk ratio values were increased significantly after 4-weeks and then returned to reduce after 8-weeks again with respect to those of zero time.

**Effect of POS on liver and renal functions**

Liver and renal performances of rats of all groups at zero time were nearly similar and in case normal. No significant differences were noticed between the values of total protein, albumin, AST and ALT of hyperlipidemic group or untreated control. The same trend was observed with uric acid and urea of all groups.

While administration of hyperlipidemic diet caused significant disruption on liver and renal functions, significant reduction was recorded after 4 and 8 weeks in total protein (19.36% and 33.33%), albumin (33.61% and 43.23%), uric acid (40.81% and 83.61%) and urea (50.13% and 84.26% respectively) of hyperlipidemic control rats with respect to each untreated control. On the other hand, significant elevation was observed after 4 and 8 weeks in AST (21.78% and 54.12%) and ALT (35.74% and 44.12%) of hyperlipidemic control rats in comparison with each untreated control.

POS treatments had a significant effect on liver functions: total protein, albumin, AST and ALT. POS enhanced total protein and albumin production significantly, while AST and ALT were declined significantly, compared with each hyperlipidemic control.

The time period showed a significant effect on liver functions, with respect to zero time. Total protein and ALT were raised after 4-weeks and then were reduced after 8-weeks, compared with those of zero time. Another trend recorded with albumin and AST which were decreased after 4-weeks and still was decreasing after 8-weeks continuously.

Total protein and albumin were augmented significantly as a response of POS treating and increasing time period (Table 4). HFD-POS-powder 10% recorded the highest augment of total protein after 4-weeks (27.65%) followed by HFD-POS-ethanolic 70% (18.80%) with respect to each hyperlipidemic control ($P \geq 0.05$). The highest improvement on albumin was recorded on HFD-POS-infusion group after 8-weeks (76.15%) followed by HFD-POS-powder 10% group after 4-weeks (30.70%) (Table 4). Globulin, which was calculated by the difference between total protein and albumin, did not change significantly in all groups at all time.

Data presented in Table 5 showed that, administration of POS preparations for 8-weeks waned AST and ALT levels of rats significantly with respect to each hyperlipidemic control ($P \geq 0.05$). The highest reduction of AST was recorded by POS-infusion after 8-weeks, 47.11%, while the lowest value of ALT was recorded in HFD-POS-ethanolic 70% group (48.61%) followed by HFD-POS-infusion group (46.82%) after 8-weeks with respect to hyperlipidemic control. POS-infusion put AST of HFD-POS-infusion group lower than that of zero time. The same observation was recorded on POS-ethanolic 70% on the case of ALT.

As for the uric acid and urea levels, POS treatments had significant effect on these rats, which administrated hyperlipidemic diet. POS-infusion recorded the highest influence on uric acid and urea, compared with each hyperlipidemic control. Time period had also significant effect on uric acid and urea. Uric acid was affected after 8-weeks than 4-weeks, with respect to that zero time. Urea was increased after 4-weeks and continued increase after 8-weeks, with respect to zero time.

Both uric acid and urea levels were reduced significantly as a response to administration of POS preparations for 8-weeks compared with hyperlipidemic control (Table 6). POS-ethanolic 70% recorded the highest decrease on uric acid (68.55%) followed by POS-powder 10% (65.28%) with respect to hyperlipidemic control. All POS preparations decreased uric acid more than those of untreated control. Both of HFD-POS-powder 10% and HFD-POS-infusion recorded the highest decrease on urea levels: 32.25% and 32.82% respectively after 4-weeks.

**Effect of POS on body weight gain, food intake, feed efficiency (EF) and relative weight of liver**

Administration of hyperlipidemic diet dwindled daily body weight gain, feed intake, feed efficiency (FE) and relative weight of liver significantly by about 22.66%, 33.97%, 14.00% and 23.35% respectively on hyperlipidemic control (data presented in Fig. 5). POS preparations decreased daily body weight gain and feed intake significantly in comparison with
hyperlipidemic control. HFD-POS-infusion group ingested the lowest amount of food (24.24%) followed by HFD-POS-ethanolic 70% group (17.80%), compared with hyperlipidemic control ($P < 0.05$; LD; 3.31). HFD-POS-ethanolic 70% group growth was the lowest growth (23.57%) followed by HFD-POS-infusion group (17.14%) with respect to hyperlipidemic control ($P < 0.05$; LSD; 0.27). The decrease in daily body weight gain was parallel with the decrease in feed intake of groups fed on POS-powder 10% and POS-ethanolic 70%, noticed through decreasing feed efficiency, while feed intake on rats treated by POS-infusion did not parallel with daily body weight gain by increasing feed intake non-significantly, with respect to hyperlipidemic control.

Relative weight of liver was decreased significantly by POS preparations treating for 8 weeks in comparison with hyperlipidemic control. POS-powder 10% recorded the highest decrease in relative weight of liver (25.25%) followed by POS-infusion (15.53%). No significant difference was noticed among relative weight of liver of HFD-POS-powder 10%, HFD-POS-infusion and untreated control.

**Histopathological studies**

Untreated control rats revealed normal hepatic lobules with normal central veins hepatic cords; sinusoids; and portal tracts (normal hepatic artery; portal vein and bile duct) (Fig. 6). Rats fed on hyperlipidemic diet showed micro vesicular steatosis with swollen and pale stained hepatocytes with granular cytoplasm central to slightly eccentric nuclei with scattered aggregates of chronic non-specific inflammatory cells i.e. lobular inflammation. Some cases showed lobules of signet ring hepatocytes with clear cytoplasm and eccentric nuclei alternating with groups of hepatocytes showing micro vesicular steatosis. The portal tract was mildly distended by chronic inflammatory cells. Liver of HFD-POS-powder 10% group showed swollen hepatocytes with vesicular cytoplasm and central nuclei. Some cases showed alternated dark areas of normal liver cords and pale areas of fatty change including micro-vesicular steatosis and macrovesicular type (signet ring fatty change). Other cases showed lobules of signet ring hepatocytes infiltrated by chronic inflammatory cells or early granuloma formation. Liver of HFD-POS-powder 10% was nearly similar to that of untreated control than those of hyperlipidemic control. In liver section of HFD-POS-infusion rats some cases showed interstitial infiltration and portal aggregation of a small foci of chronic inflammatory cells. Other cases appeared completely normal. Liver of HFD-POS-ethanolic 70% sections revealed scattered foci of mild portal inflammation, with normal hepatic lobules. POS-infusion and POS-infusion liver sections were appeared with normal structure mostly. Although feeding on hyperlipidemic diet, POS administration at any form protected liver against fatty liver damage and returned livers toward normalization.

**Discussion**

The initial phases of atherosclerotic fatty streak lesions occur when macrophages take up oxidized LDL-C, which accumulate as lipid-laden foam cells in endothelial wall of cell. Antioxidants could prevent the development of atherosclerosis by reducing LDL-C oxidation and increasing HDL-C.

In the present study POS preparations; POS-powder 10%, POS-infusion and POS-ethanolic 70%, were investigated as hypolipi-
Dietary hyperlipidemic rats were used in this study as a hyperlipidemic dietary model. These models were characterized by elevated TL, TG, VLDL-C, TC, LDL-C levels and decreased HDL-C level. This hyperlipidemic rats had highly risk ratio reached to about ten times of those of untreated control, as well as elevation on glucose and disruption on liver and renal functions. Liver of these rats showed fatty changes reached to fatty liver damage including signet ring hepatocytes and chronic inflammatory cells.

POS treatments showed significant hypoglycemic effect and the highest hypoglycemic effect recorded by POS-powder 10\%.

Obtained results are on the line of those of Fujita and Yamagami (2008) on water-soluble extract of black tea, Badal et al. (2011) on Menth piperita leaves infusion, El-Newary et al. (2011) on P. oleracea seeds, Masani et al. (2012) on vitis vinifera fruits juice. Thus, the significant antihyperglycemia activity of POS preparations may be attributed to the presence of polyphenols reported as a major role in reducing oxidative stress-associated diabetes and hyperlipidemia which helps the regulation of plasma glucose levels and hepatic glucose metabolism (Du Thie and Crozier, 2000). Many researchers confirmed that polyphenols, catechins and water-soluble polysaccharide fractions of tea reduced serum glucose.

**Table 5** Effect of *Portulaca oleracea* stems preparations on serum AST and ALT of hyperlipidemic rats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>AST</th>
<th>ALT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-day</td>
<td>4-weeks</td>
</tr>
<tr>
<td>Untreated control</td>
<td>39.31 ± 0.39</td>
<td>37.84 ± 2.49</td>
</tr>
<tr>
<td>Hyperlipidemic control</td>
<td>39.06 ± 0.57</td>
<td>46.08 ± 0.97</td>
</tr>
<tr>
<td>HFD-POS-powder 10%</td>
<td>38.66 ± 1.03</td>
<td>54.82 ± 2.01</td>
</tr>
<tr>
<td>HFD-POS-infusion 10%</td>
<td>38.80 ± 0.53</td>
<td>45.22 ± 1.81</td>
</tr>
<tr>
<td>HFD-POS-ethanolic 70%</td>
<td>37.18 ± 1.91</td>
<td>52.94 ± 0.91</td>
</tr>
<tr>
<td>Time mean</td>
<td>38.60B</td>
<td>47.38A</td>
</tr>
</tbody>
</table>

Data in table were analyzed by two ways. 
*P* ≤ 0.05, value with the same letter has no significant but value with different letter has significant at 0.05.

**Table 6** Effect of *Portulaca oleracea* stems preparations on serum uric acid and urea of hyperlipidemic rats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Uric acid</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-day</td>
<td>4-weeks</td>
</tr>
<tr>
<td>Untreated control</td>
<td>5.64 ± 0.2</td>
<td>5.05 ± 0.3</td>
</tr>
<tr>
<td>Hyperlipidemic control</td>
<td>5.33 ± 0.3</td>
<td>7.05 ± 0.6</td>
</tr>
<tr>
<td>HFD-POS-powder 10%</td>
<td>5.1 ± 0.1</td>
<td>4.65 ± 0.36</td>
</tr>
<tr>
<td>HFD-POS-infusion 10%</td>
<td>5.2 ± 0.3</td>
<td>4.75 ± 0.1</td>
</tr>
<tr>
<td>HFD-POS-ethanolic 70%</td>
<td>5.3 ± 0.05</td>
<td>4.55 ± 0.5</td>
</tr>
<tr>
<td>Time mean</td>
<td>5.3A</td>
<td>5.4A</td>
</tr>
</tbody>
</table>

Data in table were analyzed by two ways. 
*P* ≤ 0.05, value with the same letter has no significant but value with different letter has significant at 0.05.

**Fig. 5** Effect of *Portulaca oleracea* stems preparations on risk ratio of hyperlipidemic Wister Albino rats.
in rats fed high fat diet by increasing muscle glucose transporter (Bose et al., 2008; Suzuki et al., 2012). Liao et al. (2001) and Chemler et al. (2007) reported that polyphenols were able to inhibit digestive enzymes such as salivary amylase, intestinal sucrase and α-glucosidase, which reduced digestibility and promotes pancreatic β-cells regeneration.

POS preparations improved lipid profile toward normalization. This effect of POS preparations was appeared in a remarkably reduction in TL, TG and VLDL-C, TC and LDL-C, and increased HDL-C significantly, compared with hyperlipidemic control. Therefore risk ratio was reduced significantly. Among all POS preparations, POS-infusion showed the most pronounced effect on lipid metabolism of hyperlipidemic rats. These results agreed with those of Khanna et al. (2002) on Phyllanthus niruri, Lee et al. (2005) on Solanum nigrum Linne, Pourghassem-Gargari et al. (2009) on Nigella sativa L. dietary fibers, Lee et al. (2010) on buckwheat leaf and flower, Lim et al. (2013) on Artemisia capillaris, Chiang et al. (2013) on Polygonatum alte-lobatum Hayata extract, Thirumalai et al. (2014) on Piper betel, Ragab et al. (2014)

**Fig. 6** Histopathological of liver sections of rats treated with different preparation of *Portulaca oleracea* stems compared with hyperlipidemic and untreated control.
Flavonoids have been shown to possess a variety of biochemical and pharmacological activities, including hypolipidemic effects, cardio-protective and antioxidant properties (Ribeiro et al., 2001). Flavonoids decreased TC, LDL-C and VLDL-C but increased HDL-C, and may be due to increase in lipolysis more than hypoegenesis Koshy et al. (2001). POS preparations contain flavonoids about 0.52 and 1.16 g quercetin/100 g.

For Alkaloids, Francis et al. (2002) and Alexander et al. (2008) reported that alkaloids causes dryness on the mucosa in the upper gastrointestinal tract. And it prevents the binding of acetylcholine by antagonizing the muscarinic acetylcholine receptors. Since acetylcholine is the transmitter responsible for the peristaltic and segmentation movements in the small intestine, blockade of these receptors causes a delay, slowing down of activities or blocking of the smooth muscle contraction (Alexander et al., 2008). POS preparations contain high amount of crude alkaloids ranged between 1.65% and 11.68%.

POS preparations contain saponins ranged from 0.29% to 2.15% and tannins about 0.18–0.27%. Saponins prevent cholesterol absorption through interfering with its enterohepatic circulation and increasing cholesterol fecal excretion (Johnes et al., 1995). Also tannins have been reported to reduce cholesterol levels by increasing fecal bile acids excretion (Parab and Mengi, 2002).

Injury to liver tissues due to hyperlipidemia alters their transport function and membrane permeability, leading to leakage of enzymes from the cells. Therefore, the marked release of AST and ALT into the circulation indicates severe damage to hepatic tissue membranes (Ahn et al., 2007). Administration of POS returned liver and renal functions toward normalization with respect to hyperlipidemic control. This protective action of POS may be due to enhancement of hepatic steatosis and fat accumulation in liver. In this report, POS preparations improved histology of livers of rats treated rats and restored them close to untreated control liver. These results in the line of those of Ghule et al. (2009) on Lagenaria siceraria Stand. fruit, Nib et al. (2012) on Orange Juice, Kodali and Seru (2013) on Boswellia ovalifoliolata Bal, Bakr and Header (2014) on Aqueous Extract of Green Tea (Camellia Sinensis L.).

The weight loss in this study due to POS preparations administration was associated with decreasing food intake, hyperglycemia, may promote insulin sensitivity, thus lowering insulin resistance in obese rats, possibly by regulating the cell energy metabolism or reducing free fatty acids (Rajasekar and Anuradha, 2007), and decreasing of fat absorption and lipogenic enzymes and increasing of fat excretion uncoupling proteins, thermogenesis (Rains et al., 2011). In the present study reduced body weight gain may be due to improvement in gastrointestinal motility and influence colonic motility thereby reducing fluid absorption and facilitating weight loss (Amin and Nagy, 2009). These obtained finding were in accordance with those of Lee et al. (2011) on Laminaria japonica, Seo et al. (2012) on aged garlic extract, Bakr and Header (2014) on aqueous extract of green tea (C. Sinensis L.).

Conclusion

The current study was carried out to estimate the weight lowering, hypolipidemic and hepatoprotective effect of POS preparations; POS_powder 10%, POS_infusion and POS_ethanolic 70%.
on rats fed on hyperlipidemic diet. The obtained results showed that; POS preparations decreased both of daily body weight gain and daily food intake of hyperlipidemic rats. Disrupted lipid profile of rats was ameliorated significantly by administration POS preparations for 8 weeks, compared to hyperlipidemic rats. Liver status was enhanced remarkably either on liver functions or on liver histology. This hypo-lipidemic effect of POS preparations; POS-\textit{powder} 10\%, POS-\textit{infusion} and POS-\textit{ethanolic} 70\%, might be due to its contents from polyphenolics, flavonoids, alkaloids, crude fiber and mucilage, which have been documented as a hypolipidemic agents. These findings are indicating that the POS preparations; POS-\textit{powder} 10\%, POS-\textit{infusion} and POS-\textit{ethanolic} 70\% have a good weight lowering, hypolipidemic and hepatoprotective properties with margin of safety. POS did not receive the enough attention from studying and investigation, although production of stems was more economic. So it could be recommended with more studies on POS.

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References


