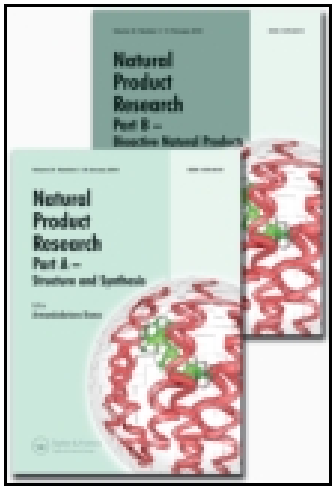

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SHORT COMMUNICATION

Hypolipidaemic and antioxidant properties of ethanol extract from *Flos populi*

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This study was undertaken to evaluate antihyperlipidaemic and *in vitro* antioxidant activity of ethanolic extract of *Flos populi* (EFP). The results demonstrated that EFP contains 78.5% flavonoids and 10.4% phenolics, and it exhibited free radical-scavenging activity on 2,2-diphenyl-picrylhydrazyl (IC_{50} 36.40 ± 0.62 μg/mL) and high reducing power (EC_{50} 206.32 ± 1.6l μg/mL) under *in vitro* chemical assays. And irrespective of prophylactic administration or remedial administration, in high fat diet-induced hyperlipidaemic mice, oral treatment with EFP produced a decrease in the levels of serum total cholesterol, triglycerides, low-density lipoprotein-cholesterol and increase in high-density lipoprotein-cholesterol. In a word, in high fat diet-fed hyperlipidaemic mice, EFP (100, 200 and 400 mg/kg) significantly altered the plasma lipid levels to near normal. These results support a potential effect of EFP in cardiovascular disease.

Keywords: *Flos populi*; flavonoids; phenols; antioxidant; hypolipidaemic

1. Introduction

The increase of serum total cholesterol (TC) and low-density lipoprotein is a primary risk factor for cardiovascular diseases (CVDs). CVDs such as coronary heart disease (CHD) and peripheral artery disease are the leading cause of death worldwide (Irudayaraj et al. 2013). Despite the multifactorial pathogenesis of CVD, high intake of calories and fats (cholesterol-rich fats and saturated fatty acids) are widely considered as major contributing factors (Rubenfire et al. 2010). Up to date, there are many drugs to reduce the risk for CHD significantly. Statins, Niacin, Fibrates, Zetia, Orlistat (Xenical) and so on are lipid-lowering drugs or allopathic hypolipidaemic drugs available widely in the market; however, these drugs would bring a lot of side effects such as hyperuricaemia, nausea, diarrhoea, severe muscle damage (myopathy), gastric irritation, flushing, dry skin and abnormal liver function (Brown 1996). This fact has led researchers to search for new molecules or herbal drugs with minor adverse effects. However, it does not go far enough. In Asia, and many other developing countries, more and more attention is cast on natural hypolipidaemic substances derived from medicinal plants to fill the lacunae created by allopathic drugs. Up to now, although it is widely distributed in China, there is little information on *Flos populi*. For the sake of making better use of the resource, more research is immediately required for efficient procedures of *F. populi*. The objective of this study was to evaluate antihyperlipidaemic activity and *in vitro* antioxidant potential of ethanolic extract of *Flos populi* (EFP).

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2. Results and discussion

2.1. *Total flavonoids and total phenols content of EFP*

Phenolic compounds in plants are viewed as powerful antioxidants due to their ability to donate hydrogen or electron, and to form stable radical intermediates (Prathapan et al. 2012). The testing result indicates that the content of total flavonoids and total phenols of EFP was 78.5% and 10.4%, respectively.

2.2. *Antioxidant activity analysis*

2.2.1. *Reducing power of EFP*

The results of the reducing power of EFP are shown in Figure 1(a). It demonstrates the reductive capabilities of EFP compared with the standard 2,6-Di-tert-butyl-4-methylphenol (BHT); the reducing power of EFP increased with increasing quantity of the sample. The EC_{50} value of EFP and BHT was 206.32 ± 1.6l μg/mL and 69.23 ± 0.2l μg/mL, respectively.

2.2.2. *Scavenging activity on DPPH radical*

2,2-Diphenyl-picrylhydrazyl (DPPH), a stable nitrogen-centred free radical, has been used to evaluate natural antioxidants for their radical-quenching capacities in a relatively short time, compared with other methods (Prathapan et al. 2011). The scavenging activities of EFP on DPPH free radical compared with the standard vitamin C are shown in Figure1(b). EFP exhibited a significant dose-dependent inhibition of DPPH activity, with a 50% inhibition (IC_{50}) at a concentration of 36.40 ± 0.62 μg/mL. The IC_{50} value of vitamin C was 33.59 ± 0.3l μg/mL.

2.3. *Lipid profile*

2.3.1. *Prophylactic administration*

The serum TC, triglycerides (TG), low-density lipoprotein-cholesterol (LDL-C) and high-density lipoprotein-cholesterol (HDL-C) levels of each group are shown in Figure 2(a), and we can conclude as follows.

After 4 weeks of feeding different diets, the serum TC and LDL-C levels of the MC group were significantly higher than those of the NC group ($p < 0.01$, $p < 0.05$), the HDL-C levels of the MC group were significantly lower than those of the NC group ($p < 0.05$), and the TG levels of the MC group was higher than those of the NC group, but there was no significant difference ($p < 0.05$). These results demonstrate convincingly that a mouse model of high TC and LDL-C, low HDL-C was successfully established.

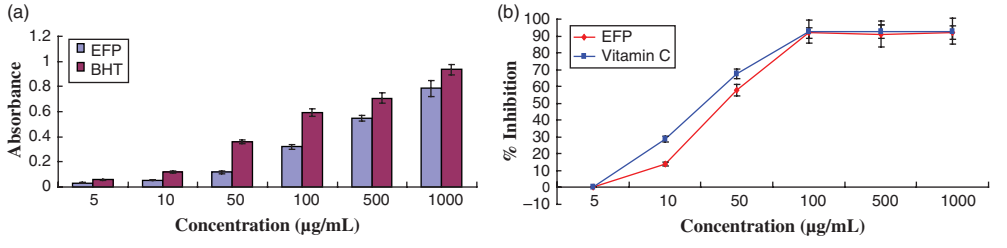

Figure 1. (a) Reductive ability of EFP and BHT. (b) DPPH radical-scavenging effect of EFP and vitamin C. Each value represents the mean ± SEM of triplicate experiments.

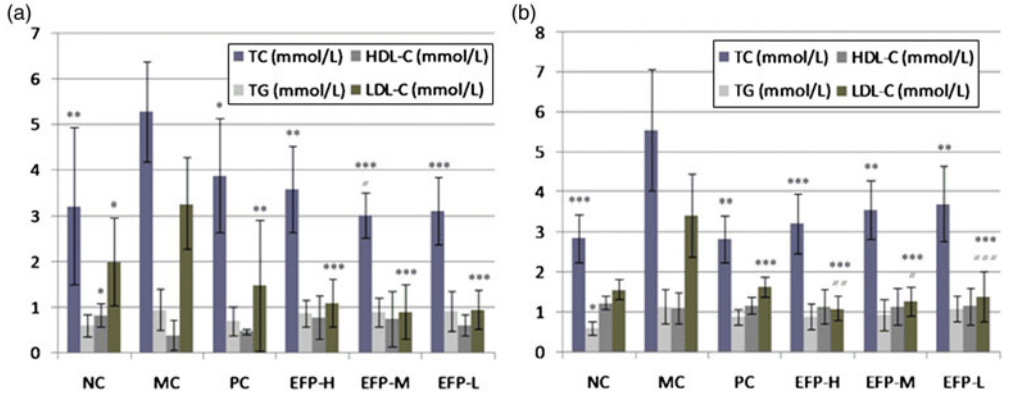

Figure 2. Effect of EFP on concentration of serum TC, TG, HDL-C and LDL-C. (a) Prophylactic administration and (b) remedial administration. ($\bar{x} \pm$ SD, $n = 8$. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, compared with the MC group; $^{\#}p < 0.05$, $^{\#\#}p < 0.01$, $^{\#\#\#}p < 0.001$, compared with the PC group.)

For the experimental group, after 4 weeks of feeding different diets and administration, the serum TC levels of EFP groups and PC group were significantly lower than those of the MC group ($p < 0.001$ for EFP-L and EFP-M, $p < 0.01$ for EFP-H, and $p < 0.05$ for PC), and TC levels of the EFP-M group were significantly lower than those of the PC group ($p < 0.05$), these results indicate that EFP could decrease the serum TC levels. The experimental groups displayed decreases in TG levels and increases in HDL-C levels compared with the MC group, but there was no significant difference ($p < 0.05$). The serum LDL-C levels of EFP groups and PC group were significantly lower than those of the MC group ($p < 0.001$ for EFP-L, EFP-M and EFP-H, $p < 0.01$ for PC), and the EFP groups displayed decreases in LDL-C levels compared with the PC group, but there was no significant difference ($p < 0.05$), these results illustrate that the serum LDL-C levels of hyperlipidaemic mice could be reduced by oral EFP.

2.3.2. *Remedial administration*

The serum TC, TG, LDL-C and HDL-C levels of each group are shown in Figure 2(b), and we can conclude as follows.

After 6 weeks of feeding different diets, the serum TC, TG and LDL-C levels of the MC group were significantly higher than those of the NC group ($p < 0.001$ for TC and LDL-C, $p < 0.05$ for TG), the HDL-C levels of the MC group were lower than those of the NC group, but there was no significant difference ($p < 0.05$). These results illustrated that a mouse model was successfully established, whose TC, TG and LDL-C were higher than those of normal.

For the experimental group, after 6 weeks of feeding different diets and administration, the serum TC levels of EFP groups and PC group were significantly lower than those of the MC group ($p < 0.001$ for EFP-H, $p < 0.01$ for EFP-L, EFP-M and PC), these results indicate that EFP could decrease the serum TC levels. The experimental groups exhibited decreases in TG levels and increases in HDL-C levels compared with the MC group, but there was no significant difference ($p < 0.05$). The serum LDL-C levels of EFP groups and PC group were significantly lower than those of the MC group ($p < 0.001$ for EFP-L, EFP-M and EFP-H, $p < 0.01$ for PC), and EFP groups exhibited significant decreases in LDL-C levels compared with the PC group ($p < 0.001$ for EFP-L, $p < 0.01$ for EFP-H and $p < 0.05$ for EFP-M), these results indicate that EFP could decrease the serum LDL-C levels.

High-fat diets significantly increase the TC levels, and high TC or LDL-C concentrations are risk factors for CHD and the development of atherosclerosis (Woo et al. 2008). In our study, we

estimated the hypolipidaemic activity of EFP (100, 200 and 400 mg/kg) in hyperlipidaemic mice. The data demonstrated that EFP could be used further in treating high fat diet-induced hyperlipidaemia.

3. Conclusion

EFP primarily comprised flavonoids and phenols, and the content was 78.5% and 10.4%, respectively. EFP exhibited significant scavenging activity on DPPH (IC_{50} 36.40 ± 0.62 μg/mL), as well as high reducing power (EC_{50} 206.32 ± 1.6l μg/mL) *in vitro*. And irrespective of prophylactic administration or remedial administration, in high fat diet-induced hyperlipidaemic mice, oral treatment with EFP produced a decrease in the levels of serum TC, TG, LDL-C and increase in HDL-C. These findings support the potential of EFP as candidates to be phytomedicines used in those CVDs where lipid-lowering effects are desired.

Supplementary material

Experimental details relating to this article are available online, alongside Tables S1 and S2.

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Note

1. These authors contributed equally to this work.

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