Hypolipidemic Effects from an Aqueous Extract of Xiao Tuocha in High-Fat Diet-Induced Hyperlipidemia Mice

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Abstract

Hypolipidemic effects of Tuocha aqueous extract were studied and the functional constituents from the extract were analyzed by HPLC. Results have shown that the contents of tea polyphenol etc., in raw Tuocha were higher than that in fermented Tuocha, whereas the fermented Tuocha had higher gallic acid content compared to the raw Tuocha. Lovastatin was detected in the fermented Tuocha extract. Tuocha extract can reduce body weight gain, food efficiency ratio (FER), atherogenic indexes (AI) and improve the lipid profiles by lowering serum total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-C) levels and increasing high-density lipoprotein cholesterol (HDL-C) levels significantly. A gavage dose, at 2000 mg/kg/day of Tuocha extract, can realize the most significant declines of TC, TG, LDL-C and AI by 35.4-36.8%, 65.6-49.7%, 54.1-50.1%, 77.7-79.5% respectively, and an increase of HDL-C to more than 97.1%, as compared to the HF group. Pure lovastatin or tea polyphenols can also cause a significant hypolipidemic effect, but the effect provided by lovastatin or tea polyphenols is lower than that of Tuocha containing the same amount of counterpart, which suggests that hypolipidemic effect of Tuocha may be caused by synergistic effects of tea components.

Keywords: Xiao Tuocha; functional costituents; hypolipidemic effect

1. INTRODUCTION

Nowadays, cardiovascular disease has become one of the three top diseases that kill the mid-aged and the elderly throughout the world. Elevated levels of serum total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) are considered as the major contributing factors for cardiovascular disease (Thongngam & McClements, 2005; Zhang, et al., 2008). Literatures have reported higher incidence of cardiovascular disease, making this disease appears to be common. In order to reduce the risk of cardiovascular disease, the Pu-erh tea, an accepted cholesterol-lowering beverage, was encouraged to consume.

Pu-erh tea, as a hypolipidemic beverage, has received considerable attention. This is partly because it contains relatively high levels of tea polyphenols, especially flavan-3-ols which are considered as being able to help suppress fatty acid synthase expression (Chiang et al., 2006) and reduce the level of total cholesterol (Kuo et
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al., 2005). What’s more, it is even believed that tea polyphenols are the only active ingredients responsible for hypolipidemic effects in Pu-erh tea. Song et al. (1998) investigated the effect of tea polyphenols on serum indexes in hyperlipidemia rats, and the results also proved that tea polyphenols can prevent and control hyperlipidemia by lowering the concentration of total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C). However, further studies confirmed that the hypolipidemic functions of tea (ripe Pu-erh tea) with lower polyphenols contents are even better than that of the tea (raw Pu-erh) with higher polyphenols contents. Therefore, people suspected that there may be other unknown biochemical constituents involved in preventing and controlling hyperlipidemia. The finding of lovastatin, another important active ingredient in Pu-erh tea, provides a new idea to reveal the mechanism behind the hypolipidemic functions of Pu-erh tea (Hwang et al., 2003; Deng et al., 2006).

Xiao Tuocha, as a new and small-size compressed Pu-erh tea, is made from crude sun-dried leaves of Camellia sinensis (Linn.) var. assamica (Mast.) Kitamura, a tea variety produced in Yunnan province, China. It can be classified into raw Tuocha and fermented Tuocha according to their processing procedure (Zhao et al., 2010). The Xiao Tuocha is different from the traditional Pu-erh tea due to the introduction of the latest tea material’s formula, which is a new technology of compressing to form small-size Tuo shape and combing with its distinctive local characteristics of microbial fermentation in different districts. This maybe played a great role in forming its specific flavors and tastes (Sano et al., 1986).

Though many researchers have been conducted on biochemical components, quality formation and its hypolipidemic effects of Pu-erh tea and raw Tuocha (Xu et al., 2005; Wu et al., 2004; Zhao et al., 2010), the functional constituents and hypolipidemic activities about the Xiao Tuocha, a newly small-size compressed Pu-erh tea products, were not still reported. This study was endeavored to investigate the effect of an aqueous extract of Xiao Tuocha on lipid profile, along with quantitative estimation of tea polyphenols, constituents of catechins, lovastatin and other main ingredients present in Xiao Tuocha for the purpose of fully understanding the mechanisms responsible for hypolipidemic effects.

2. MATERIALS AND METHODS

2.1. TEA SAMPLES

A total of 26 representative Xiao Tuocha tea samples, including newly-produced raw Xiao Tuocha (n=12) and fermented Xiao Tuocha (n=12), fermented Xiao Tuocha stored for five years (n=2) were provided by 6 middle and large-sized Pu-erh tea companies in Yunnan province.

2.2. CHEMICALS AND DIETS

Pure standard of mevinolin, caffeine, gallic acid and hydroxymethyl glutaryl Coenzyme A (HMG-CoA) were purchased from Sigma (St. Louis, MO). Unless stated, all solvents were considered as HPLC grade, chemicals as analytical grade and water as purified on a Milli-Q system (Millipore, Bedford, MA).

The components of diets were shown in Table 1. HF diet was an atherogenic diet. Cholesterol, sodium cholate, yolk powder and basic feed were purchased from Chongqing Tengxin Laboratory Animal Co. Ltd., Chongqing, and PR China. Lard and tea polyphenol (purity 97%) were purchased respectively from a local market in Wuxi, PR China and Jubang Plant Material Co. Ltd., in Shifang, PR China.
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Table 1 Composition of the experimental diets (%)

<table>
<thead>
<tr>
<th>Component</th>
<th>NC</th>
<th>HF</th>
<th>HF+RT</th>
<th>HF+FT</th>
<th>HF+Lv</th>
<th>HF+PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Dl-methionine</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Cera acid</td>
<td>15</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mineral elements</td>
<td>1.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Protein</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Choline</td>
<td>0.2</td>
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<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Metal oil</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
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<td>free</td>
<td>free</td>
<td>free</td>
<td>free</td>
<td>free</td>
<td>free</td>
</tr>
</tbody>
</table>

2.3. PREPARATION OF THE TEA EXTRACT

Tea extract was prepared by adding tea powder, 25 g to 500 mL of boiling distilled water, steeped for 30 min. The extraction solution was cooled to room temperature and then filtered. The residue was discarded and the filtrate was freeze-dried. The final dehydrated powder was then dissolved in distilled water to appropriate concentration for subsequent research.

2.4. ANIMAL STUDY AND EXPERIMENTAL DESIGN

Table 2 Groups supplemented with different gavage dose of Xiao Tuocha

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number</th>
<th>Administrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>HF</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>HF+RT</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>HF+FT</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>HF+Lv</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>HF+PP</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

One hundred and forty-six male mice (C57BL/6N mice of 4 weeks of age, weighing 12 g, were purchased from Chongqing Tengxin Laboratory Animal Co. Ltd., Chongqing, PR China) were placed individually in an air-conditioned room (24± 2 °G with relative humidity of 45-55% under a 12 h light/dark cycle. Mice had free access to consume standard diet and water ad libitum and were acclimated to the conditions for 1 week. All were then randomly divided into 12 dietary groups (Table2).

Groups I and II (each consisting of eight animals) were fed with a normal control (NC) and high fat diets (HF), respectively. The gavage dose was designed according to the no-observed-adverse-effect level of 2500 mg/kg body weight/day for green tea extract (Hsu et al., 2011). Therefore, groups III-X (n=14 per group) were arranged to receive high fat diets (HF) supplemented with different gavage doses of aqueous extract of raw Xiao Tuocha (RT) and fermented Xiao Tuocha (FT) (600, 1000, 2000, and 3000 mg Xiao Tuocha/kg body weight/day), Group XI (n=8) received high fat diet (HF) + 0.16 μg lovastatin/kg body weight/day (roughly equivalent to lovastatin contained in 2000 mg fermented Xiao Tuocha), Group XII (n=8) received high fat diet (HF) supplemented with a gavage dose of 240 mg tea polyphenols/kg body weight/day (roughly equivalent to tea polyphenols contained in 2000 mg fermented Xiao Tuocha). All the mice were gavaged five times a week. The NC and HF groups received gavage of distilled water with the same volume as the other groups.

The mice were fed for 6 weeks and allowed free access to food and water during the experimental period. The food consumption and weight gain were measured daily and weekly, respectively. At the end of the experimental period, the mice were anaesthetized with ketamine-HCl following a 12-h fast. Blood samples were drawn from the inferior vena cava into a heparin-coated tube and centrifuged at 1000 g for 15 min at 4 °C to obtain the plasma. The body organs (liver and kidney) were removed to ice cold containers for various estimations. The current study protocol was approved by the Ethics Committee of Southwest University and Yangtze University for animal studies.
2.5. BIOCHEMICAL ANALYSIS

2.5.1. FUNCTIONAL CONSTITUENTS

The tea polyphenols, water extract and protein contents in the Xiao Tuocha were evaluated by the methods described by Liao et al. (2002). Caffeine, flavan-3-ols (please write which components from this group were analyzes?) and potential lovastatin concentrations in Xiao Tuocha were determined by methods of high-performance liquid chromatography (HPLC) described by Xu et al. (2005) and Zhao et al. (2013) respectively.

2.5.2. DETERMINATION OF SERUM LIPID PROFILE

The concentrations of serum total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were determined using the assay kits (obtained from Shanghai Beihai Biotechnology Co.Ltd., Shanghai, PR China) according to the manufacturer’s instructions.

Three independent measurements were conducted for each sample in order to check the reproducibility of the obtained data. Arteriosclerosis index (AI) was calculated as described by Queiroz-Monici, Costa, da Silva, Reis, and de Oliveira (2005).

\[ AI = \frac{TC - (HDL-C)}{HDL-C} \]

Where TC is serum total cholesterol, HDL-C is high-density lipoprotein cholesterol.

2.5.3. 3-HYDROXY-3-METHYLGLUTARYL COA (HMG-CoA) REDUCTASE AND SUPEROXIDE DISMUTASE (SOD) ACTIVITIES

The activity of HMG-CoA reductase was estimated in liver samples by measuring reduced coenzyme A formed in the reaction using the method of spectrophotometric procedure described by Hulcher and Oleson (1973). Superoxide dismutase (SOD) activities were determined using commercially available kits (purchased from Shanghai Meilian Biotechnology Co.Ltd., Shanghai, PR China) according to the manufacturer’s instructions.

2.6. STATISTICAL ANALYSIS

All values are expressed as the mean ± SD. The statistical analyses were conducted using SPSS 13.0 for Windows software (SPSS Institute Inc., Cary NC). The obtained results are analyzed by ANOVA followed by post test (Bonferroni; one way and two ways) and significant levels are p < 0.05.

3. RESULTS

3.1. MAIN CONSTITUENTS OF XIAO TUOCHA

The main constituents (water extract, proteins, tea polyphenols, caffeine, gallic acid, and lovastatin) of 26 Xiao Tuocha samples were determined (Table 3). The contents of water extract and tea polyphenols were significantly higher in raw Tuocha than that in fermented Tuocha, whereas the fermented Tuocha has higher gallic acid content than raw Tuocha. The contents of protein and caffeine were not significantly different between raw and fermented Tuocha samples.

Table 3 also shows that no lovastatin was detected in the raw Tuocha samples without further aging, either because the samples did not contain lovastatin or lovastatin was below the detection limit (0.01 ng/g). However, after post-fermentation, almost all the fermented Xiao Tuocha samples were detected to containLovastatin with the concentrations from 0.08±0.02 μg/g to 0.09±0.01 μg/g.
3.2. COMPOSITIONS OF CATECHIN IN XIAO TUOCHA

Table 4 shows the catechin composition in Xiao Tuocha extract used for this study. The total amount of catechins in raw Tuocha, fermented Tuocha and fermented Tuocha stored for 5 years were 24.59±0.36 mg/g, 7.75±0.61 mg/g, 3.67±0.57 mg/g respectively. (−)-Epicatechin gallate (ECG), (−)-Epigallocatechin gallate (EGCG), (−)-Epicatechin (EC) and (−)-Catechin (C) were the major catechins identified in raw Tuocha, comprising about 89.18% of total catechins. Dominating flavan-3-ols identified in the fermented Tuocha extract were (+)-catechin (C), (−)-Epicatechin (EC), (−)-Epigallocatechin gallate (EGCG) and (−)-Epicatechin gallate (ECG). The contents of ester type catechins (including EGCG, ECG and GCG) and non-ester type catechins (EGC, D-C and EC) were higher in raw Tuocha than that in fermented Tuocha. The ratio of ester type catechins to non-ester type catechins in raw Tuocha, fermented Tuocha and fermented Tuocha stored for 5 years were 2.55, 1.7 and 0.54 respectively, which was negatively correlated with the degree of fermentation of Xiao Tuocha.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Raw Tuocha</th>
<th>Fermented Tuocha</th>
<th>Fermented Tuocha stored for 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total flavan-3-ols</td>
<td>24.59±0.36</td>
<td>7.75±0.61</td>
<td>3.67±0.57</td>
</tr>
<tr>
<td>(−)-Epigallocatechin (EGC)</td>
<td>0.85±0.05</td>
<td>0.33±0.15</td>
<td>0.32±0.06</td>
</tr>
<tr>
<td>(−)-Catechin (C)</td>
<td>2.81±0.02</td>
<td>0.65±0.08</td>
<td>0.58±0.07</td>
</tr>
<tr>
<td>(−)-Epicatechin (EC)</td>
<td>3.26±0.12</td>
<td>1.82±0.13</td>
<td>1.47±0.09</td>
</tr>
<tr>
<td>(−)-Epigallocatechin gallate (EGCG)</td>
<td>6.99±0.01</td>
<td>1.86±0.11</td>
<td>0.49±0.28</td>
</tr>
<tr>
<td>(−)-Gallocatechin gallate (GCG)</td>
<td>1.85±0.07</td>
<td>0.62±0.04</td>
<td>0.16±0.01</td>
</tr>
<tr>
<td>(−)-Epicatechin gallate (ECG)</td>
<td>9.15±0.09</td>
<td>2.47±0.10</td>
<td>0.65±0.06</td>
</tr>
</tbody>
</table>

3.3. BODY WEIGHT GAIN AND ORGAN WEIGHTS

Prior to feeding with the experimental diets, there was no significant difference in the body weights of mice (Table 5). At the end of the experimental period, however, a marked increase (from 16.73±0.14 to 45.94±0.61 g) in the body weight of HF mice was observed. The body weights of HF groups supplemented with different gavage concentrations of aqueous extract of raw Tuocha, fermented Tuocha, lovastatin and tea polyphenols (groups from Ⅲ to Ⅹ) remained higher than that of the normal control group, but decreased significantly compared to those of the HF mice. Compared with the HF+RT mice groups, HF+FT mice groups supplemented with the same gavage doses of aqueous extract of Xiao Tuocha exhibited better effect in body weight loss. For whichever mice group, HF+RT or HF+FT, the body weights declined as gavage dose of aqueous extract of Tuocha increases. The effect of HF+Lov group (Ⅹ) in body weight loss was lower than that of HF+FT group (group Ⅸ) supplemented with fermented Xiao Tuoch containing the equal amount of lovastatin, and the effect of HF+PP (group ⅩⅠ) in body weight loss was also lower than that of HF+RT group (group Ⅴ) supplemented with Xiao raw Tuocha containing the equal amount of tea polyphenols. However, HF+Lov group (Ⅹ) acquired a smaller body weight than the group of HF+PP (Ⅹ). HF+RT, HF+FT, HF+Lov and HF+PP mice groups showed significantly higher daily feed intake compared to the HF group, however their food efficiency ratio (FER) were similar to that of the NC mice but lower than that of the HF mice. There was no significant difference in the weights of liver and heart between the experimental diet-fed groups and control group, whereas slight decrease in the kidney weight were found in HF+RT and HF+FT groups compared with the NC and HF mice.
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3.4. SERUM LIPIDS

Significant (P < 0.05) changes of the lipid levels in HF group mice were induced by feeding high-fat diet with a raise in serum TC (up to 5.67±0.83 mmol/L), TG (up to 1.69±0.32 mmol/L), LDL-C levels (up to 3.81±1.29 mmol/L) and the ratio of total cholesterol to HDL-C, accompanied by a decrease in HDL-C level (Table 6). Compared with the HF group, the treatment groups (including HF+RT, HF+FT, HF+Lov and HF+PP) significantly decreased their levels of serum TC, TG, LDL-C (P < 0.05), nevertheless, the levels of serum HDL-C was significantly higher in groups of HF+RT, HF+FT, HF+Lov and HF+PP than that in the positive control group (NC) and HF group (P < 0.05). The serum TC, TG and LDL-C levels were lowered while the HDL-C levels were increased significantly in mice of HF+RT and HF+FT groups with increasing gavage concentration of raw and fermented Tuocha extract (P < 0.05). A gavage dose, at 2000 mg/kg/day of raw Tuocha extract, can realize the most significant declines in serum TC, TG, LDL-C and AI by 35.4%, 65.6%, 54.1% and 77.7% respectively, and an increase of HDL-C to 97.1%, as compared to the HF group (P < 0.05). The fermented Tuocha extract was more effective on reducing atherogenic indexes than the same concentration of raw Tuocha extract. Meanwhile, results also show that there was a positive correlation between AI-reducing effect and gavage concentration of Tuocha extract.

3.5. HMG-CoA REDUCTASE AND SUPEROXIDE DISMUTASE (SOD) ACTIVITIES

As shown in Fig. 1, it was observed that high fat cholesterol supplementation significantly increased the hepatic HMG-CoA reductase activity by 83.71% (in HF group), compared to the NC group mice. Hepatic HMG-CoA reductase activities were also significantly lowered in the HF+RT and HF+FT groups by 8.10-17.34% and 17.99-43.44% respectively (p < 0.05), as compared to the HF group. The HF+Lov and HF+PP groups decreased the hepatic HMG-CoA reductase activity by 9.67% and 16.63%, respectively, as compared to the HF group mice.
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High fat cholesterol diets caused significant decreases in the activity of serum superoxide dismutase (SOD). After treatment for 6 weeks with different gavage dose of Tuocha aqueous extract, lovastatin and tea polyphenols, the serum SOD activities were significantly increased by 12.41-27.03% (in HF mice groups supplemented with raw Tuocha, from group III to VI), 4.34-15.79% (in HF mice groups supplemented with fermented Tuocha, from group VII to X), 6.52% (in HF mice groups supplemented with lovastatin, group XI) and 22.71% (in HF mice groups supplemented with tea polyphenols, group XII).

4. DISCUSSION

Hyperlipidemia is a kind of lipid metabolism disorder, which is characterized by elevated levels of serum total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C) and lowered levels of serum high-density lipoprotein cholesterol (HDL-C) (Zhang et al., 2009). Atherogenic index (AI) is an important parameter that determines the degree of carotid artery atherosclerosis. High cholesterol diets can increase the body weight, serum TC and LDL-C levels, resulting in an increased risk for the development of atherosclerosis. In the current study, it is believed that Tuocha extract can reduce body weight gain, FER, AI and improve lipid profiles by lowering serum TC, TG and LDL-C concentration levels compared to the HF group. This is consistent with the previous studies where Pu-erh tea will contribute to reducing serum levels of lipids and lipoproteins (Hou et al., 2009).

Tea polyphenols, flavan-3-ols, caffeine, lovastatin are the major components of health benefits in Pu-erh tea, including Tuocha variety. They have been suggested to have hypolipidemic and anti-obesity effects on various dyslipidemic animal models (Kao et al., 2006, zhao et al., 2013). Tea polyphenols, ester type catechins and non-ester type catechins, which are enriched in raw Tuocha, are dramatically reduced in fermented Tuocha. Gallic acid is one of the most prominent phenolic acids in Tuocha, and its content in fermented Tuocha was higher than in raw Tuocha. It is likely that tea polyphenols, especially the catechins, are susceptible to undergo a series of oxidative and degradative chemical processes to form low molecular compounds during the post-fermentation process of Tuocha (Chen et al., 1985, Zhou et al., 2004).

Our results have shown that the fermentation process will rarely affect the caffeine levels in Tuocha, namely, there is no significant difference between raw Tuocha and fermented Tuocha with regard to the caffeine levels. Different dose of raw Tuocha aqueous extract can significantly boost the excitement of mice nerve in HF+RT groups, however, HF+FT groups supplemented with the same dose of fermented Tuocha aqueous extract have the nearly normal manefestation, which suggests that the caffeine from raw Tuocha with similar levels have a stronger ability to improve excitement of nerve than the caffeine from fermented Tuocha. This may be linked to the existing forms of caffeine in raw or fermented Tuocha (Lv et al., 2013).

Tea polyphenols, a new natural antioxidant existing in Xiao Tuocha, may contribute to hypolipidemic activity by increasing the activity of serum SOD and modulating the enzymes involved in cholesterol metabolism, such as...
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HMG CoA reductase, etc. (Chen et al., 2003, Hou et al., 2009). The present study has indicated that Tuocha extract supplementation significantly increased serum SOD activities and reduced hepatic HMG-CoA reductase activities, and raw Tuocha with higher tea polyphenols levels was better in improving the activity of serum SOD than the fermented Tuocha with lower tea polyphenols levels, while the suppressing effect of fermented Tuocha on hepatic HMG-CoA reductase activity was more notable than that of raw Tuocha, which suggests that the mechanisms of hypolipidemic activity provided by raw Tuocha were different from fermented Tuocha. It is probably because the hypolipidemic activity of raw Tuocha mainly depends on tea polyphenols and its antioxidant activity. The fact that lovastatin was not detected in raw Tuocha but was found in almost all the fermented Tuocha shows lovastatin may be produced by microorganisms such as Penicillium spp., Trichoderma spp etc. (Endo et al., 1986, Zhao et al., 2013) during the post-fermention process of Tuocha. The hypolipidemic properties of lovastatin are well established and are most likely the major contributors to lowering the LDL and total cholesterol after daily administration of Xiao Tuocha extract.

This study reveals that both lovastatin and tea polyphenols will cause significant hypolipidemic effects by increasing serum SOD activities, suppressing hepatic HMG-CoA reductase activity and improving lipid profiles etc. However, hypolipidemic effects provided by pure lovastatin or tea polyphenols were significantly lower than that of Xiao Tuocha containing the same amount of lovastatin or tea polyphenols, which indicates that hypolipidemic effects of Tuocha may be caused by synergistic effects of tea components and some bioactive metabolites, such as lovastatin, are derived from microorganisms during the maturation of Xiao Tuocha.

5. CONCLUSIONS
In conclusion, the current results indicate that supplementation of Xiao Tuocha aqueous extract, which is rich in polyphenol compounds etc. can decrease serum TC, TG, LDL-C, and increase serum HDL-C of HF groups that is partly mediated via the combined effects of various biochemical components in Xiao Tuocha aqueous extract. Hypolipidemic efficacy of XiaoTuocha provided evidence that this functional beverage can be developed as a potential natural product to prevent the hyperlipidemia.

6. ACKNOWLEDGMENTS
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