Study on the Anti-Fatigue and Lipid-Lowering Effects of American Ginseng Polysaccharides

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T American ginseng (Panax quinquefolius), a perennial herb belonging to the Araliaceae family, is primarily cultivated in the United States and Canada, with successful introduction in certain regions of China in recent years. Traditional Chinese medicine (TCM) classifies American ginseng as cold in nature, with a slightly sweet and bitter taste, possessing the functions of replenishing Qi, nourishing Yin, clearing heat, and generating fluids. Over the years, extensive research has been conducted on American ginseng, leading to significant advancements in its pharmacological applications.

In modern society, with the improvement in living standards, obesity has become increasingly prevalent, contributing to various metabolic disorders such as hyperlipidemia, diabetes, cardiovascular diseases, hypertension, atherosclerosis, and fatty liver, posing a severe threat to human health. Pancreatic lipase is the key enzyme responsible for dietary fat hydrolysis, accounting for 50%–70% of total fat digestion. Inhibiting pancreatic lipase activity is an effective strategy to control obesity induced by high-fat diets. Existing studies have demonstrated that both Panax ginseng and Panax quinquefolius can inhibit pancreatic lipase activity, thereby reducing body weight, fat mass, blood lipid levels, and hepatic lipid accumulation in high-fat diet-fed mice.

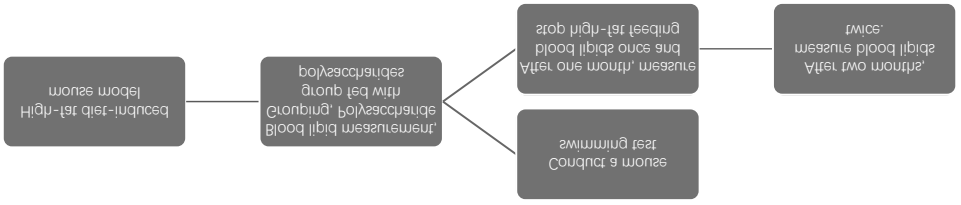
Most current research on American ginseng focuses on its highly active ginsenosides, with well-documented and reliable findings. Recent studies have shown that different parts of Panax ginseng and Panax quinquefolius, as well as various types of ginsenosides, exhibit significant pancreatic lipase inhibitory activity, promoting lipid hydrolysis and preventing obesity. Clinically, numerous American ginseng formulations, such as lozenges and pills, have been applied in cardiovascular disease treatments. Panax quinquefolius stem and leaf total saponins (PQSs), extracted from the stems and leaves of American ginseng, have been demonstrated to exert protective effects against myocardial infarction, with diol-type ginsenosides exhibiting cardioprotective activity and triol-type ginsenosides displaying endothelial-protective effects. These findings suggest that American ginseng holds great potential as a lipid-lowering and anti-obesity agent.

However, another active component of American ginseng, polysaccharides, remains largely unexplored regarding its lipid-lowering and anti-fatigue properties. Therefore, this study aims to investigate the effects of American ginseng

polysaccharides in these domains, providing new insights into their pharmacological potential.

1 Materials and Methods

1.1 Experimental Procedure



1.2 Experimental Animals

Twelve wild-type C57 mice (6 weeks old, body weight 18–22 g) were provided by VITAL RIVER Laboratories.

1.3 Reagents

American ginseng polysaccharides were extracted in our laboratory.

1.4 Animal Modeling

Eight mice were fed a high-fat diet, while four mice served as the control group and were fed a standard diet.

The composition of the high-fat diet was as follows: 78.8% standard chow, 1% cholesterol, 10% egg yolk powder, 10% lard, and 0.2% bile salts.

Mice were housed in a barrier system with a temperature of 18°C–22°C and a relative humidity of 40%–70% for four weeks.

1.5 Grouping and Administration

After four weeks of high-fat feeding, fasting blood was collected via retro-orbital bleeding from the eight mice, and serum levels of triglycerides (TG) and cholesterol (TC) were measured. Based on serum cholesterol levels, with consideration of triglyceride levels, the high-fat diet mice were randomly divided into two groups:

·High-fat group

·Polysaccharide-treated group (60 mg/mL)

The remaining four mice, which were not fed a high-fat diet, served as the control group. After four weeks of drug administration, blood lipid levels were measured once. Subsequently, high-fat feeding was discontinued, and all mice were switched to a standard diet. Blood lipid levels were measured once per month for two additional time points.

1.6 Observations and Methods

1.6.1 Mouse Swimming Test

Three large beakers (50 cm in height, 20 cm in diameter) were prepared, each filled with 30 cm of water at 25°C.

The mice were divided into three groups and placed in the beakers, ensuring that their hind legs and tails did not touch the bottom. The starting time was recorded.

When a mouse stopped swimming and its head remained submerged for 4 seconds, it was removed from the water. The total swimming duration was recorded.

1.6.2 Lipid-Lowering Experiment

Fasting blood was collected via retro-orbital bleeding using blood collection tubes. The blood samples were then transferred to centrifuge tubes and centrifuged at 12,000 r/min for 10 minutes. Serum was collected using a micropipette and transferred to a 96-well plate. Reagents were sequentially added according to the reaction protocol, and absorbance values were measured using a microplate reader. TC and TG levels were calculated using formulas established in our laboratory.

1.7 Data Analysis

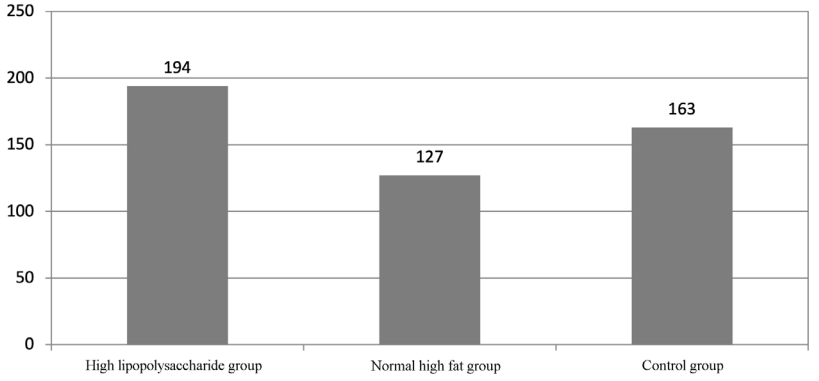
Statistical analysis was performed using the correction formula in SPSS 10.0 software.

2 Experimental Results

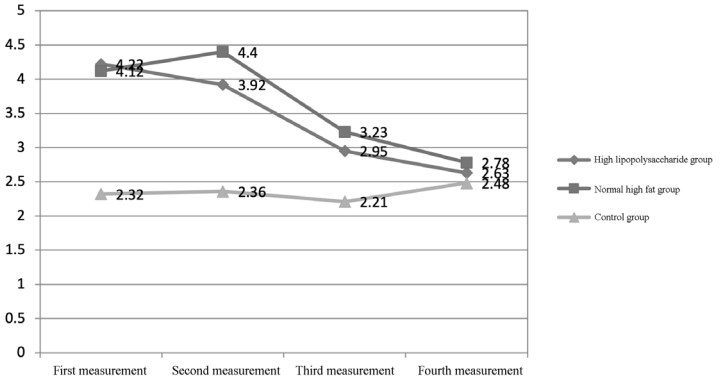
2.1 Swimming Test Results

Group	Animal	Swimming Duration
High-fat polysaccharide group	4	194 ± 7.87
Regular high-fat group	4	127 ± 6.24
Control group	4	165 ± 9.84

The results showed that, compared to the regular high-fat group, the swimming duration of mice in the high-fat polysaccharide group was significantly prolonged (194 ± 7.87 vs. 127 ± 6.24). Additionally, the swimming duration in the high-fat polysaccharide group was also extended compared to the control group (194 ± 7.87 vs. 163 ± 9.84). These findings indicate that American ginseng polysaccharides exhibit a significant anti-fatigue effect ($p < 0.05$).



2.2 Cholesterol Levels (TC) in Mice



The data showed that during the second measurement, the blood lipid levels in the high-fat polysaccharide group

exhibited a decreasing trend, whereas those in the regular high-fat group continued to rise. Notably, at this time point, the mice were still on a high-fat diet, indicating that American ginseng polysaccharides effectively reduce blood lipid levels in high-fat diet-induced mice. After the second measurement, high-fat feeding was discontinued, and blood lipid levels in both the high-fat polysaccharide group and the regular high-fat group displayed a downward trend. However, the decline was significantly more rapid in the high-fat polysaccharide group compared to the regular high-fat group, further confirming the lipid-lowering effects of American ginseng polysaccharides.

	Second	Third	Third
Reduction in the polysaccharide group relative to the regular high-fat group	12.7%	8.7%	5.4%

The data indicated that, based on intergroup comparisons, the reduction in blood lipid levels was greater in the high-fat polysaccharide group than in the regular high-fat group in each measurement ($p < 0.05$).

3 Discussion

American ginseng (Panax quinquefolius) is known for its blood-nourishing, Yin-tonifying, spleen-strengthening, and Qi-boosting properties. It possesses extensive biological activities, with its primary active components including polysaccharides, ginsenosides, and trace elements. In recent years, several studies have reported on the lipid-lowering and anti-fatigue effects of American ginseng. Therefore, this study focused on one of its key components, American ginseng polysaccharides, to evaluate their potential anti-fatigue and lipid-lowering effects through high-fat diet modeling, polysaccharide extraction, mouse cultivation, and animal experiments.

In the investigation of the anti-fatigue effects of American ginseng polysaccharides, a comparison of swimming durations between high-fat diet mice and control mice demonstrated that healthy mice exhibited significantly greater endurance than hyperlipidemic mice. This finding further confirmed the critical role of maintaining normal blood lipid levels in sustaining regular physiological functions. High-fat diets lead to elevated cholesterol levels, which in turn contribute to atherosclerosis, coronary ischemia, and insufficient myocardial blood perfusion, ultimately impairing circulatory function and reducing blood supply to muscles, thereby causing fatigue. The experimental results indicated that the swimming duration of mice in the polysaccharide-treated group was 53.4% longer than that of the regular high-fat group, highlighting the significant anti-fatigue effect of American ginseng polysaccharides and their potential to enhance exercise capacity in mice. This effect is likely attributed to the ability of American ginseng polysaccharides to improve blood circulation. Additionally, the swimming duration of the polysaccharide-treated group was 19.0% longer than that of the control group, suggesting that their effect may not be solely due to lowering serum cholesterol levels. It is hypothesized that American ginseng polysaccharides might also promote glycogen metabolism in the liver or enhance energy conversion via other mechanisms, leading to increased exercise capacity and improved fatigue resistance. Moreover, since high-fat diet-fed mice exhibited enhanced endurance after polysaccharide administration, it is reasonable to speculate that normal mice receiving polysaccharide supplementation would experience an even greater improvement in fatigue resistance. Therefore, this study provides evidence that American ginseng polysaccharides have promising anti-fatigue properties.

In the lipid-lowering study, triglyceride (TG) levels among the three experimental groups did not show significant differences across measurements, suggesting that American ginseng polysaccharides did not have a notable effect on reducing serum triglyceride levels in mice. However, cholesterol (TC) levels, a major factor contributing to atherosclerosis, were significantly affected. The data demonstrated that American ginseng polysaccharides effectively reduced elevated

blood cholesterol levels, exhibiting potent lipid-lowering effects. The experimental design, which involved initial high-fat diet modeling followed by standard diet feeding, was intended to better highlight the lipid-lowering effects of American ginseng polysaccharides. The results revealed that the cholesterol levels of mice in the polysaccharide-treated group declined at a significantly faster rate than those in the regular high-fat group. Moreover, intergroup comparisons across multiple measurements consistently demonstrated the significant lipid-lowering effect of American ginseng polysaccharides. These findings suggest that, under appropriate dietary control and polysaccharide administration, hyperlipidemia in mice can be effectively ameliorated. Collectively, these results provide strong evidence for the cholesterol-lowering potential of American ginseng polysaccharides.

The anti-fatigue and lipid-lowering effects of American ginseng polysaccharides are likely due to their ability to enhance metabolic function and improve overall physiological health. However, the precise underlying mechanisms require further investigation.

Several studies have suggested that ginsenosides exhibit even greater lipid-lowering activity, whereas their anti-fatigue effects are relatively weak. Therefore, the observed anti-fatigue properties of American ginseng can primarily be attributed to its polysaccharide content. While American ginseng products may confer substantial health benefits, their whole-plant consumption is not recommended, especially for adolescents, as the hormonal components in American ginseng may lead to precocious puberty or other developmental abnormalities. Additionally, excessive intake of ginsenosides alone may cause hyperactivity-related symptoms due to their potent bioactivity. In contrast, American ginseng polysaccharides exhibit a more balanced pharmacological profile, making them a more suitable option for the majority of individuals.

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