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Full Length Research Paper

Antifatigue effects of polydatin from Chinese herb *Polygonum Cuspidatum* in swimming mice

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This study evaluated the antifatigue polydatin from Chinese herb *Polygonum Cuspidatum* (PFPC) in ICR mice by swimming endurance test. Forty male mice were studied by being divided into 4 groups (ten for each group), as follows: Group I (control group, CG), Group □ (low-dose group, LDG), Group □ (medium-dose group, MDG) and Group □(high-dose group, HDG). The control group was given distilled water and the treatment groups were given various doses of PFPC (20, 40, 60 mg/kg) for 28 consecutive days, respectively. The result showed that PFPC had significant antifatigue effects in mice. It extended the swimming time, increased concentration of the hemoglobin (Hb), prevented the increase in lactate and blood urea nitrogen (BUN) concentrations.

Key words: Polydatin, *Polygonum cuspidatum*, antifatigue.

INTRODUCTION

Polygonum cuspidatum (Chinese name: Hu Zhang) belongs to the Polygonaceae, Knotweed family, Perennial herbaceous, with height 1-1.5 m. Rhizome grows underground, in yellow color. Stem is coarse, strong and straight, with no hairs on the surface, and small flower in pale or light pale-green color (Li et al., 2003). The plant grows widely in different areas of China and it is one of the traditional Chinese herb in common use with its root and rhizome to treat infectious hepatitis, icterus neonatorum, cholelithiasis, cholecystitis with dampness-heat or severe heat syndrome, leucorrhagia, pruritus vulvae of the dampness-heat type, mycotictrichomoniasis, and bacterial vaginitis (mainly local use). It is also used to treat burns, snake bites, carbunculosis, amenorrhea, dysmenorrhea, trauma with blood stasis, and rheumatism (Zhao et al., 2005; Zhang et al., 2007). Extensive phytochemical and pharmacological studies have shown that resveratrol, polydatin, anthraglycoside B (emodin-8-O-β-D-glucoside), emodin and physcion in *P. cuspidatum* have biological activities contributing to the traditional efficacy of the herb (Hua et al., 2001; Gu et al., 2006; Lu et al., 2006; Zhang et al., 2007).

Polydatin,3,4′,5-trihydroxystilbene-3-β-mono-D-glucoside, is an important stilbenoid and posesses several activities proved by previous studies: It exerts a neuroprotective effect on cerebral injury induced by ischemia/reperfusion (Cheng et al., 2006; Zhang et al., 2008), promotes weight loss and enhances diet attitudes in low-income mothers of young children (Jordan et al., 2008), and protects the primarily cultured rat hepatocytes against CCl_4-induced injury (Huang et al., 1999; Xing et al., 2008). Recent studies also report that it can reduce lipid oxidation (Pan et al., 2007), resist free-radical, kill or inhibit tumor cells, inhibit of platelet aggregation and antibacterial (Shu, 2002; Shu et al., 2004; Zhu and Jin, 2005; Zhu et al., 2007). But the antifatigue effects of Polydatin have not been reported. The aim of present study is to investigate the antifatigue effect of polydatin from *P. cuspidatum* (PFPC).

MATERIALS AND METHODS

Polydatin

Polydatin was isolated and purified from the root and rhizome of *P. cuspidatum* by Neptunus Pharmaceutical Co. Ltd. (Shenzhen, China) and appeared as white powder. (Molecular formula $C_{20}H_{22}O_8$;

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molecular weight: 390.40; purity > 90%).

Animals and grouping

Male ICR mice weighing approximately 18 to 22 g were obtained from Yunnan Academy of Medical Sciences (Kunming, China) and housed individually in plastic cages at 20 to 30°C, relative air humidity of 45 to 55%, with lighting on from 6:00 AM to 6:00 PM. Mice were provided a basal diet and water *ad libitum.* The basal diets consists of corn starch 45%, bran28%, bone meal 5%, fish flour 15%, corn oil 3.0%, mineral mix 3.5%, salt 0.4%,Vitamin mix 0.1% (the Disease Control Center, Yunnan, China). The approval of this experiment was obtained from the Institutional Animal Ethics Committee of Yunnan Normal University (Kunming, China) and was carried out according to the "Principles of Laboratory Animal Care" (World Health Organization (WHO) Chronicle, 1985). Forty male ICR mice were randomized into 4 groups equally based on body weight after one week adoption, with ten mice per group:

Group I (CTG): control mice treated with distilled water.
Group α (LDG): mice treated with low-dose PFPC (20 mg/kg).
Group β (MDG): mice treated with medium-dose PFPC (40 mg/kg).
Group χ (HDG): mice treated with high-dose PFPC (60 mg/kg/)

The volume of administration was 0.5 ml, and the treatments lasted for 28 days by gavage.

Antifatigue effects

Antifatigue effects were assessed 30 min after the final PFPC was administered. The apparatus used in this test was an acrylic plastic pool (50×40×50cm) filled with water maintained at 25±0.5ºC. The water in the acrylic plastic pool was 40 cm deep. The mice were loaded with a lead block weighing approximately 5% of their body weight attached to the tails (Ju, 2006; Li et al., 2006; Hu et al., 2008; Cao, 2008). It was reported that this arrangement forced the mice to maintain contnuous rapid leg movement (Bostrom et al., 1974). The end point of the swimming endurance was taken as when the mouse remained at the bottom for more than 8 s, then swimming endurance time was measured (Technical Standards for Testing and Assessment of Health Food, Ministry of Health, PR China, 2003).

Serum preparation for lactate, blood urea nitrogen, and hemoglobin analyses

In order to clarify antifatigue mechanism, lactate, blood urea nitrogen (BUN), and hemoglobin (Hb) concentration were measured in the forced swimming treated mice (Jung et al., 2004; Wang et al., 2006). The measurements were conducted before and after swimming. Blood samples were collected from the veins on the tails of individual mice, and the lactate, BUN, and Hb concentrations were determined by using a commercial diagnostic kit provided by Jiancheng Diagnostic Systems (Nanjing, China).

Statistical analysis

All data were presented as mean±SD. The paired t-test was used to compare the data within groups and ANOVA was used to compare the data between groups. $p < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Effect of the PFPC on body weight in ICR mice

Table 1 showed the change of body weight of the mice during the experimental period. The weights of the mice were measured after they were gavaged by different dosages of PFPC for 28 days. For the CTG, the body weights at day 0 and day 28 were 20.47±1.20 and 27.43±3.23 g, respectively. For the LDG, the body weights at day 0 and day 28 were 19.86±1.42 and 28.15±2.41 g, respectively. For the MDG, the body weights at day 0 and day 28 were 20.39±1.75 and 27.84±2.74 g, respectively. For the HDG, the body weights at day 0 and day 28 were 20.12±1.31 and 28.64±3.17 g, respectively. Results showed that the increased weights in the treated groups were of no significant difference compared with the control group ($p > 0.05$), which means PFPC had no effect on body weight.

Table 1. Effect of the polydatin from Polygonum Cuspidatum on body weight in ICR mice (mean ± SD, n=10).

Group	body weight	
	Before experiment (day 0)	After experiment (day 28)
CTG	20.47±1.21	27.43±3.23
LDG	19.86±1.42	28.15±2.41
MDG	20.39±1.75	27.84±2.74
HDG	20.12±1.31	28.64±3.17

Swimming endurance test

Swimming endurance test was employed in our study to evaluate antifatigue activity of PFPC on ICR mice. It was commonly accepted that swimming was an experimental exercise model (Lapvetelainen et al., 1997; Jung et al., 2004). Figure 1 showed that the swimming time of each treatment group increased significantly ($p<0.05$) when compared with that of the CTG. The swimming time of the LDG, MDG and HDG increased by 39.84, 65.04 and 78.05%, respectively. These results indicated that different doses of PFPC had significant effect on the endurance of the mice in the experimental and the dosage of 60 mg/kg was more effective.

Effect of the PFPC on blood lactate in ICR mice

Blood lactate is the glycolysis product of carbohydrate under an anaerobic condition, and glycolysis is the main energy source for fierce exercise in a short time. Therefore, blood lactate is closely related to workload intensity and is one of the important indicators for judging the intensity of the exercise or the degree of fatigue. In other words, blood lactate represents the degree of fatigue after exercise and the condition of recovery (Wang et al., 2006; Yu et al., 2008). As shown in Table 2, there was no significant difference in the concentration of blood lactate treatment groups and the control group before swimming ($p >0.05$). After swimming, the concentration of blood lac-

Table 3. Effect of the polydatin from *Polygonum Cuspidatum* on BUN and hemoglobin in ICR mice (mean ± SD, n=10).

Group	BUN(mmol/l)		Hemoglobin(g/l)	
	Before swimming	After swimming	Before swimming	After swimming
CTG	13.59±1.88	21.72±3.18	153.26±6.38	140.18±8.23
LDG	13.47±2.16	20.29±3.46	152.48±5.39	145.89±9.46
MDG	13.41±2.03	18.76±3.05	155.32±4.13	156.82±9.81
HDG	13.54±1.95	18.21±2.95	153.98±7.82	154.73±11.25

$p < 0.05$ as compared with the CTG

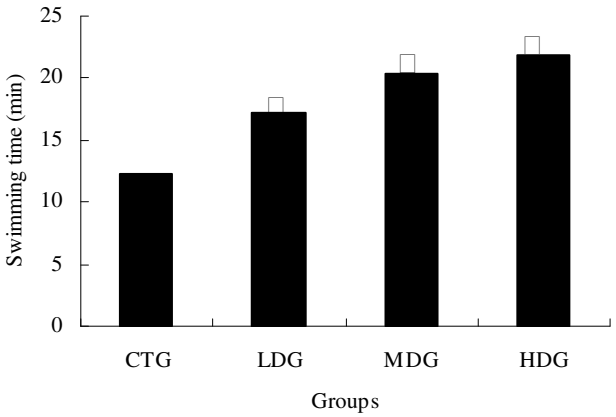

Figure 1. Effect of the polydatin from Polygonum Cuspidatum on swimming time in ICR mice (mean ± SD, n=10) $p < 0.05$ as compared with the CTG

Table 2. Effect of the Polydatin from Polygonum Cuspidatum on Blood Lactate in ICR mice (mean ± SD, n=10)

Group	Lactate (mmol/l)		Increase ratios (%)
	Before swimming	After swimming	
CTG	4.26±0.47	10.13±1.37	138
LDG	4.11±0.55	8.82±1.26	115
MDG	4.17±0.31	8.03±1.49	93
HDG	4.23±0.64	7.87±1.14	86

Increase ratio = (a- b)/b
a-the blood lactate concentration of mice after swimming;
b-the blood lactate concentration of mice before swimming;
$p < 0.05$ as compared with the CTG

tate for the treatment groups were significantly lower than that of control group ($p < 0.05$). The increase ratios of the blood lactate of the LDG, MDG and HDG were 115, 93 and 86%, respectively, which were lower than the increase ratio of 138% achieved by CTG. Judging from the increase ratio of blood lactate concentration, it could be seen that the treatment groups did possess the ability to retard and lower the blood lactate produced after exercise.

Effect of the PFPC on BUN in ICR mice

BUN is the metabolism outcome of protein and amino acid. Urea is formed in the liver and is carried by the blood to the kidneys for excretion. Because urea is separated from the bloodstream by the kidneys, urea nitrogen concentration in the blood can be used as the indication of renal function. However, there are many factors other than renal disease that can cause BUN alteration. This includes protein breakdown, dehydration, stress, fatigue, etc. The BUN value was found to increase significantly after exercise (Wu, 1999; Xu and Luo, 2001; Wang et al., 2003; Wang et al., 2006). Therefore, it is considered that BUN are important blood biochemical parameters related to fatigue. The BUN changes before and after swimming for all the groups were shown in Table 3. It was found that BUN concentration of each group had no significant difference ($p>0.05$) before swimming. However, after swimming, BUN of MDG and HDG were significantly lower than that of CTG. ($p<0.05$).

It indicated that medium–dose and high-dose PFPC possessed the ability to lower or retard the formation of BUN after exercise.

Effect of the PFPC on hemoglobin in ICR mice

Hemoglobin (Hb) is the main component of erythrocyte. Its main function is to serve as the carrier for the erythrocyte to transport oxygen and partial carbon dioxide. Hb also has the effect on maintaining the body fluid's acid–alkali balance. Therefore, it can directly affect the substance metabolism and the energy metabolism in the body and, in turn, affect body function and exercise ability of the human body, the exercise's loading capacity, and fatigue. Hb normally is one of the indicators to reflect the degree of recovery from fatigue after exercise, and in a certain range higher level of Hb is helpful to improve the exercise ability (Wang et al., 2006; Gao and Wu, 2008). As shown in Table 3, it could be seen that the difference among the hemoglobin concentration of each group before swimming was not significant. However, the hemoglobin concentration of MDG and HDG were significantly increased than that of CTG after swimming. The results showed that PFPC could affect the concentration of the Hb in the blood of mice after exercise, and dosage of 40

and 60 mg/kg were more effective.

Conclusions

Our results suggested that PFPC had significant antifatigue effects in mice. it extended the swimming time, increased concentration of the Hb, prevent the increase in lactate and BUN concentrations. Further studies to clarify the detailed mechanisms involved in the antifatigue properties of PFPC are necessary.

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