USE OF IDHP IN PREPARATION OF DRUG OR HEALTH PRODUCT FOR PREVENTION AND TREATMENT OF CORONARY ATHEROSCLEROSIS DISEASE

[0001] The present application claims priority to Chinese Patent Application No. 201610876752.3, entitled "USE OF IDHP IN PREPARATION OF DRUG OR HEALTH PRODUCT FOR PREVENTION AND TREATMENT OF CORONARY ATHEROSCLEROSIS DISEASE" filed with SIPO on October 08, 2016, and the entire content of which is hereby incorporated by reference.

FIELD

[0002] The present disclosure relates to a new use of *β*-(3,4-dihydroxyphenyl)-α-hydroxyisopropyl propionate (IDHP), in particular to the use of IDPH for the manufacture of a medicament or healthcare food in prevention and treatment of diseases related to coronary artery atherosclerosis.

BACKGROUND

[0003] *β*-(3,4-Dihydroxyphenyl)-α- hydroxyisopropyl propionate (IDHP) is an active compound screened from a large number of metabolites and their series of modifications during the research on Danshen Dripping Pills, Guanxin Danshen Tablets, Danshen Drink and other compound Danshen prescriptions, and Jun-Shi pair herbs by using HPLC-MS, GC-MS, GC-FTIR, MS, NMR and other technical methods of metabolomics technology. IDHP can also be synthesized.

SUMMARY

[0004] The inventors explored the role of IDHP in inhibiting platelet aggregation, promoting angiogenesis, etc., which provided a valuable theoretical basis for development of new drugs and

healthcare foods for prevention and treatment of coronary atherosclerosis-related diseases.

[0005] Coronary artery atherosclerosis is a type of disease caused by the buildup of plaque inside coronary artery that cause stenosis or obstruction of the vascular lumen, resulting in ischemia, hypoxia or necrosis. Common coronary atherosclerosis-related disease is coronary heart disease, stroke and myocardial infarction (MI). The major pathogenesis of coronary heart disease is closely related to the unstable coronary atherosclerotic plaque and the formation of thrombosis. Platelet aggregation is an important factor resulting in thrombosis, so antiplatelet therapy plays an important role in the prevention and treatment of coronary heart diseases. Stroke refers to a high-risk disease that, for a patient with cerebrovascular disease, various factors will induce cerebral artery stenosis, occlusion or rupture, resulting in acute cerebral circulation dysfunction, and clinically manifested as transient or permanent brain dysfunction. Antiplatelet therapy plays an important role in the primary and secondary prevention of stroke, and is currently recognized as one of the three major treatments (surgery, anticoagulation and antiplatelet aggregation). In addition, the occurrence and treatment of coronary artery atherosclerosis-related diseases are closely related to angiogenesis. Pathological neovascularization often occurs in atherosclerotic plaques, which can promote the development of atherosclerotic lesions, and even induce plaque hemorrhage and plaque rupture and its complications. The density of neovascularization around the infarction site of ischemic stroke is directly related to the survival rate of patients with ischemic stroke, and promoting angiogenesis after ischemic stroke is conducive to saving the ischemic penumbra. Angiogenesis is also a key process in coronary reperfusion and ischemic myocardium repair. In addition, pro-angiogenesis plays a significant role after recovery from myocardial infarction. The inventors' studies show that IDHP can significantly inhibit ADP or collagen-induced human platelet aggregation, and at the same time, IDHP can significantly promote angiogenesis in primary human umbilical vein endothelial cells (HUVEC). This result indicates that IDHP can be used to prepare drugs for prevention and treatment of diseases related to coronary artery atherosclerosis.

[0006] The inventors found that IDHP can significantly inhibit ADP or collagen-induced human platelet aggregation, which becomes a basis for using IDHP in the development of anti-platelet aggregation drugs.

[0007] The inventors found that IDHP can significantly promote angiogenesis in primary human umbilical vein endothelial cells (HUVEC), and IDHP can also significantly promotes the growth of zebrafish intersegmental vessels and posterior longitudinal blood vessels, which indicates that IDHP can be used to prepare drugs for promoting angiogenesis.

[0008] IDHP can significantly inhibit human platelet aggregation and promote angiogenesis, improve blood circulation, and thereby can be used to treat vascular dementia.

[0009] By acute and chronic toxicity tests and hemolysis experiments in mice, the inventors found that the safety of IDHP is relatively high. In combination with the above activity findings, IDHP can be used to develop healthcare foods for preventing and treating coronary artery atherosclerosis, anti-platelet aggregation, promoting angiogenesis, and preventing and treating vascular dementia.

[0010] The inventors found that IDHP is a human body-derived substance. By intaking IDHP, the balance state of the body can be regulated, to achieve the purpose of prevention and treatment of coronary atherosclerosis-related diseases and vascular dementia.

BRIEF DESCRIPTION OF DRAWINGS

[0011] Figure 1 shows the effect of different concentrations of IDHP on the proliferation of human umbilical vein endothelial cells;

[0012] Figure 2 shows the effect of different concentrations of IDHP on the migration of human umbilical vein endothelial cells;

[0013] Figure 3 shows the effect of different concentrations of IDHP on the tube formation of human umbilical vein endothelial cells;

[0014] Figure 4 shows the effect of IDHP on growth of zebrafish intersegmental vessels,

wherein: A, PTK 787; B, 0.01 μM IDHP; C, 0.1 μM IDHP; D, 1.0 μM IDHP; E, 10.0 μM IDHP; F, 10 nM VEGF;

[0015] Figure 5 shows the result of the growth of intersegmental vessels promoted by IDHP in zebrafish;

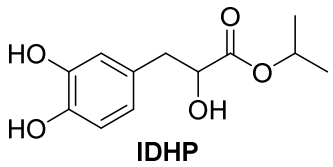
[0016] Figure 6 shows the effect of IDHP on ADP and collagen-induced normal human platelet aggregation (n=16);

[0017] Figure 7 shows the identification of IDHP by mass spectrum;

[0018] Figure 8 shows the identification of IDHP by liquid chromatography.

DETAILED DESCRIPTION

[0019] The structure of IDHP compound of the present disclosure is as shown in the following formula, and the preparation method thereof can be referred to CN 200410026205.3, but is not limited to the description of the literature.



IDHP

[0020] The healthcare foods mentioned in the present disclosure may be a soft capsule, a dropping pill, an emulsion, a tablet, a spray, etc.

Example 1: IDHP Promotes Angiogenesis of Cultured Human Umbilical Vein Endothelial Cells (HUVEC) *In Vitro*

1.1 Detect Proliferation of Human Umbilical Vein Endothelial Cells Promoted by IDHP — CCK-8 Method

[0021] Human umbilical vein endothelial cells were seeded in a 96-well plate at a density of approximately 2,500 cells per well. After the cells were culture for 24 hours, the medium was changed for a fresh medium containing drug, 100 μl/well, and the cells were continued culturing

for 48 hours. 2 hours before the end of drug treatment, CCK-8 reagent was added to the culture medium in the dark, 10 μl per well. The culture was continued for 2 hours, and then the absorbance at 450 nm was determined with a microplate reader to calculate the cell proliferation rate. The result is shown in Figure 1. Compared with the blank control group, IDHP significantly promoted the proliferation of vascular endothelial cell at a concentration of 10^{-9} to 10^{-7} M ($P < 0.01$).

1.2 Detect Migration of Human Umbilical Vein Endothelial Cells (HUVEC) Promoted by IDHP — Scratch Method

[0022] Endothelial cells were seeded on a cover slip pre-coated with gelatin in a 24-well plate at a density of about 10^5 cells per well. After the cells attached to the cover slip and reached confluence, cells were starved in a medium without serum for 4 hours. A home-made tool was used to make scratch on the cover slip with cells. The cover slip was washed twice with PBS, and a medium containing drug was added, 600 μl/well. Control group was immediately fixed with ice-cold methanol at zero time point; rest of the cells were cultured for 16 hours, and then fixed with ice-cold methanol. Images were acquired under a microscope and subjected to statistics analysis. The result (Figure 2) shows that IDHP could promote the migration of human umbilical vein endothelial cells (HUVEC) in a dose-dependent manner at a concentration range of 10^{-10} to 10^{-7} M.

1.3 Detect Tube Formation of Human Umbilical Vein Endothelial Cells (HUVEC) Promoted by IDHP — Matrigel Gel Method

[0023] Pipette tips and 96-well plate were pre-cooled at -20 °C. Matrigel gel was placed on ice and melted, and then added to the pre-cooled 96-well plate (60 μl/well). Avoid the formation of air bubbles. The plate was placed on ice for 5 minutes to level the Matrigel gel, and then put into a cell culture incubator for 30 minutes to solidify. Endothelial cells were added to the wells (5×10^4 cells/well) containing Matrigel gel, and fresh medium containing different concentrations of the drug was added, incubated at 37 °C for 8 hours. The plate was observed under a

microscope, 5 fields of view were chosen at 0, 3, 6, 9 o'clock positions and the center of each well, the number of tubules and the integrity of the tubular structure were observed and images were acquired. The result shows that, compared with the Ctrl control group, IDHP significantly promoted the tube formation of primary human umbilical vein endothelial cells (HUVEC), indicating that IDHP has an activity of promoting angiogenesis *in vitro*.

Example 2 IDHP Promotes Angiogenesis in Transgenic Zebrafish

[0024] The transgenic Tg (VEGFR2:GFP) zebrafishes were cultured under the standard conditions of illumination for 14 hours /dark for 10 hours at 28 °C. Healthy and mature zebrafishes were put into a breeding container at a ratio of female to male 1/1 or 1/2 for mating. The fertilized eggs were obtained at 9 to 10 o'clock the next day. The fertilized eggs were sterilized and washed, then transferred to zebrafish embryo culture medium and cultured at 28 °C.

[0025] Drug solution was added to a 24-well culture plate, and 24 hpf embryos were carefully transferred to wells, 8-10 per well, and culture medium was added until a total volume of 2 ml to make sure that the final concentration of DMSO in the medium was not higher than 1%. After 24-hour drug treatment, the embryos were observed under a fluorescence microscope, and the total number of intersegmental vessels in trunk and tail were counted, and the relative generation rate of ISV in each administration group was calculated. Analysis of variance between groups was performed using SPSS software.

[0026] The result shows that IDHP at concentrations of 0.01, 0.1 and 1.0 μM, respectively, significantly promoted the growth of intersegmental vessels and posterior longitudinal blood vessels in zebrafish (Figure 4) with a significant increase in the total number and length of blood vessels (Table 1). According to the formula: relative generation rate (%) = (total length of blood vessels in the drug treatment group - total length of blood vessels in the control group of PTK787) ÷ total blood pressure of normal control group × 100, the relative generation rate was calculated,

and the result showed a dose-dependent relationship of the drug treatment (Figure 5).

Table 1 The Promotion Effect of IDHP on the Growth of Zebrafish ISV

Name	Concentration	Length of Blood Vessels (μm)	Number of Blood Vessels
DMSO	0.1%	785.1 ± 49.5	28.9 ± 3.8
PTK787	0.1 μg/ml	36.4 ± 14.2	3.6 ± 1.3
VEGF	10 ng/ml	420.0 ± 54.2	29.3 ± 3.3
IDHP	0.01 μM	287.4 ± 18.8***	25.0 ± 8.6***
	0.1 μM	359.2 ± 58.2***	26.1 ± 3.3***
	1.0 μM	447.6 ± 19.5***	34.4 ± 7.0***

Note: *** represents $p<0.001$ compared with the control

Example 3 IDHP Inhibits Normal Human Platelet Aggregation Induced by ADP and Collagen

[0027] The whole blood samples of healthy volunteers were collected into the anticoagulant tubes and centrifuged at 800 g for 5 minutes at room temperature. The light yellow supernatant was the platelet-rich plasma (PRP); the remaining solution was further centrifuged at 4000 g for 10minutes at room temperature, and the supernatant obtained was platelet-poor plasma (PPP).

[0028] PRP was adjusted to 3×10^5 platelets /μl with PPP, 300 μl of adjusted PRP was added to 30 μl of PBS or different concentrations of IDHP and incubated at 37 °C for 3 minutes in a blood coagulation apparatus. Collagen or ADP at a final concentration of 3 μmol/L was added to initiate the aggregation reaction of platelets. The inhibitory effect of IDHP and clopidogrel on platelet aggregation was determined by turbidimetry. The result in Figure 6 shows that clopidogrel significantly inhibited ADP-induced platelet aggregation in the measured concentration range ($p < 0.001$); compared with ADP alone or collagen alone groups (Ctrl), IDHP respectively and significantly inhibit ADP- or collagen-induced platelet aggregation, and

the inhibitory effect on collagen-induced platelet aggregation was more significant ($P < 0.001$).

Example 4 Toxicological Study of IDHP

4.1 Acute Toxicity Test in Mice with Rapid Administration

[0029] Sixty mice were used, half male and half female, and randomly divided into 6 groups. IDHP was formulated into six concentrations using physiological saline: 3.145%, 2.68%, 2.4%, 2%, 1.875% and 1.6%. The spacing between the concentrations was 1:0.9. After the animals were fasted for 12 hours, each group was subjected to IV administration, the volume was 20 ml/kg, and the administration was completed within 5 seconds for each animal. The doses of the six groups were 629 mg/kg, 530 mg/kg, 480 mg/kg, 400 mg/kg, 375 mg/kg, and 320 mg/kg, respectively. After the IV, the animal represented shortness of breath, rapid heartbeat, jumping and convulsions, followed by slow movement and lying on the ground. The poisoning phenomenon increased with the increase of the dose; the dead animals basically died within 1 minute after the administration, and the undead animals returned to normal after 10 minutes. The dead mice was subjected to autopsy, observed by naked eyes, there was no abnormality in the vital organs such as heart, liver, spleen, lung, kidney, brain, stomach or intestine., LD_{50} was measured by the Bliss method and the value was 424 ± 58 mg/kg, the 95% confidence interval was 370 to 486 mg/kg, as shown in Table 2.

Table 2 LD_{50} of IDHP Measured by Bliss's Method

Dose mg/kg	Logarithmic Dose	Number of Animals	Mortality Rate (%)	Test Probability Unit	Regression Probability Unit	Error ($\times 10^{-6}$)
629	2.798	10	100	6.96	7.24	2.13
530	2.724	10	100	6.96	6.26	2.53
480	2.681	10	50	5.00	5.7	2.77
400	2.602	10	40	4.75	4.66	3.19

375	2.574	10	40	4.75	4.3	3.34
320	2.505	10	0	3.04	3.4	3.72

Base Mortality Rate: 0%

Significance index: G=0.1760 X50=-0.3722 Sx=0.0158 G is relatively small, omitted

Heterogeneity check: Chi2=6.90 Chi2.05=9.64 Sb=2.7993 No heterogeneity

Regression Equation Formula: Y(Probit)=9.8687+13.0795×log(D) r=0.8716

LD_{50} = 424.4 ± 39.7（mg/kg）

Feiller Heterogeneity Correction: Sx=0.0229 Sb=3.6778

LD_{50} = 424.4 ± 57.9 (mg/kg)

95% confidence interval was 370.4 to 486.2 mg/kg.

4.2 Acute Toxicity Test in Mice with Slow Administration

[0030] After housing in the laboratory for 1 day, the test mice with qualified body weight were selected and randomly divided into groups according to body weight and sex, 10 for each group, half male and half female. According to the result of premeasurement, the absolute lethal dose was 2.4 g/kg. The mice were subjected to tail vein administration, the dose for the mice was calculated according to body weight. The doses were 2.4 g/kg, 2.2 g/kg, 2.0 g/kg, and 1.8 g/kg, respectively, and the drug delivery rate was calculated. The administration was completed within 10 minutes. The reactions of the mice were observed after the administration and the death of the mice was recorded within 14 days.

[0031] The main toxic reactions after intravenous administration were central inhibition, respiratory failure, etc. Most of the death occurred during the administration period. No abnormal changes were found in anatomy. After 14 days of observation, the mortality rate of the mice was calculated. LD_{50} was measured by the Bliss method and the value was 2.048 g/kg ± 0.085 g/kg, 95% confidence limit was 1.965 to 2.135 g/kg, the result is shown in Table 3:

Table 3 LD_{50} of IDHP Measured by Bliss's Method in Mice Administered via Tail Vein

Group	Number of Mice	Dose (d) g/kg	Number of	Mortality Rate

			Deaths (n)	(%)
1	11	2.4	10	100
2	10	2.2	8	80
3	10	2.0	3	30
4	10	1.8	1	10

4.3 Hemolysis Assay

[0032] Arterial blood from domestic rabbit was collected, fibrin was removed, red blood cells were washed with physiological saline and then formulated into a 2% red blood cell physiological saline solution. The test was operated according to Table 4, four parallel test tubes in each group.

Table 4

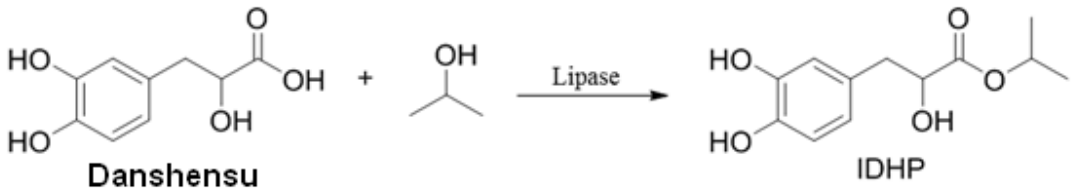
Group	Control Group	IDHP Group (10^{-3} mol/l)				
		2	4	6	8	10
IDHP Solution (ml)	/	0.1	0.2	0.3	0.4	0.5
Physiological Saline (ml)	2.5	2.4	2.3	2.2	2.1	2.0
2% red blood cell (ml)	2.5	2.5	2.5	2.5	2.5	2.5

[0033] After the above operation, the tubes were put in water bath at 37 ± 0.5 °C, one tube from each group was taken at 0.5 h, 1 h, 2 h and 3 h respectively, centrifuged at 3000rpm for 15 minutes. Red blood cell hemolysis was observed, at the same time, the morphology of red blood cells was observed under light microscope.

[0034] The test result shows that the red blood cells were intact, there was no obvious hemolysis, suggesting that IDHP has no hemolysis effect.

Example 5: Endogenous study of IDHP

[0035] Lipase-catalyzed synthesis of IDHP from isopropanol and Danshensu.



[0036] For specific implementation, refer to but is not limited to the following solution:

[0037] Danshensu (5.0 mg, 0.025 mmol), isopropanol (0.3 mg, 0.005 mmol), water (1.5 ml) and lipase (5 mg) were sealed, put in a shaker (220 rpm) and incubated at 37 °C for 24 hours. 100 μl of the reaction solution was taken, added with 100 μl of ethyl acetate, and shaked for 20 seconds. The organic phase was subjected to liquid chromatography and mass spectrum. The mass spectrum result ([M-1] = 239.0965) is shown in Figure 7; the liquid chromatography result is shown in Figure 8.

[0038] Liquid chromatography detection conditions were, methanol : 0.2% formic acid water = 3 : 7; flow rate: 0.6 ml/min; chromatography column: C18 (zorbax), 250 mm, 5 μm, 4.6 mm (inner diameter); column temperature: 25 °C.

[0039] Combined with the inventors' previous research in which it was found that Danshensu is a human body-derived substance, also, lipase widely presents in animals, plants and microorganisms (such as molds, bacteria) tissues containing fats, and human body contains isopropanol, suggesting that IDHP is an endogenous substance of human body.

Example 6: IDHP Emulsion

[0040] The emulsion formula was, IDHP: 10.0 g, vitamin E: 3.0 g, refined soybean: 200.0 g, oleic acid: 15.0 g, refined protein lecithin: 25.0 g, water for injection: about 900 ml, glycerol: 2.0 g.

Example 7: IDHP Dropping Pill

[0041] IDHP: 10.4 g, starch: 6.3 g, sodium carboxymethyl starch: 1.8 g, polyethylene glycol

(molecular weight 6000): 26.5 g. During the preparation, prescription amount of IDHP and polyethylene glycol 6000 were heated to 80 °C to get melted, and then starch and sodium carboxymethyl starch were added, mixed well, dripped into liquid paraffin coolant (1 to 5 °C) to make 1000 pills, 45 mg per pill. Traces of oil on the surface were removed to obtain the final product.

[0042] The present disclosure has been described in detail above including its preferred embodiments. However, it should be understood that, considering what is disclosed in the present disclosure, a person having ordinary skill in the art can make modifications and/or improvements to the present disclosure within the spirit and scope of the invention, which also fall within the scope of the present disclosure.

Claims

1. Use of *β*-(3,4-dihydroxyphenyl)-α- hydroxyisopropyl propionate (IDHP) for the manufacture of a medicament in prevention and treatment of a disease related to coronary artery atherosclerosis.

2. The use according to claim 1, wherein the disease related to coronary artery atherosclerosis is one or more selected from the group consisting of stroke, coronary heart disease and myocardial infarction.

3. Use of IDHP for the manufacture of a healthcare food in prevention and treatment of a disease related to coronary artery atherosclerosis.

4. The use according to claim 3, wherein the disease related to coronary artery atherosclerosis is one or more selected from the group consisting of stroke, coronary heart disease and myocardial infarction.

5. Use of IDHP for the manufacture of a medicament for inhibiting platelet aggregation.

6. Use of IDHP for the manufacture of a healthcare food for inhibiting platelet aggregation.

7. Use of IDHP for the manufacture of a medicament for promoting angiogenesis.

8. Use of IDHP for the manufacture of a healthcare food for promoting angiogenesis.

9. Use of IDHP for the manufacture of a medicament in prevention and treatment of vascular

dementia.

10. Use of IDHP for the manufacture of a healthcare food in prevention and treatment of vascular dementia.