

Review

Research development on volatile oil from chuanxiong rhizoma

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Chuanxiong Rhizoma, as an authentic herbal medicine of Sichuan province, is one of the main plant sources of Umbelliferae rhizoma which has been used to treat headache, rheumatic arthralgia and coronary heart diseases. The current review covers its chemical constituents, pharmacological activities, pharmacokinetic and combination therapy. The phytochemistry of Chuanxiong Rhizoma has been studied extensively in recent decades with many investigations that focused on tetramethylpyrazine and ferulic acid that is considered as active components of Chuanxiong Rhizoma. However, the quantities of tetramethylpyrazine and ferulic acid in Chuanxiong Rhizoma are lower when compared with volatile oil accounting for a considerable proportion of it. Senkyunolide A and ligustilide belong to volatile oil and have been reported as main active components of Chuanxiong Rhizoma. Pharmacokinetic studies are important for the application to understand the therapeutic and toxicity of the Chinese traditional medicine, although numerous animal studies have demonstrated the pharmacokinetic process of volatile oil; few clinical trials are conducted. Therefore, large randomized clinical trials and further scientific researches to determine its mechanism of actions will be necessary to ensure the safety, effect and better understanding of its action.

Key words: Chuanxiong Rhizoma, volatile oil, chemical study, pharmacology, pharmacokinetics.

INTRODUCTION

Chuanxiong Rhizoma, like most traditional Chinese medicine (TCM) herbs, has been used clinically over thousand years in China. The first recorded is in the Divine Husbandmans Classic of the Materia Medica (Shen Nong Ben Cao Jing). It belongs to the Umbelliferae family, Ligustrum genus. Chuanxiong Rhizoma is warm in property and pungent in flavor according to TCM theory and is used for the treatment of headache, rheumatic arthralgia and coronary heart diseases (China Pharmacopoeia Committee, 2005). The volatile oil compounds in this medicinal plant are recognized as important part for its pharmacological activities mentioned earlier. In addition to single-herb preparations, various Chuanxiong Rhizoma-based proprietary products are also used in clinical practice. For example, Quick-Acting Heart-Saving Pill (Chinese name: Suxiao Jiuxin Wan), a

contains Chuanxiong Rhizoma essential oil extract as the primary ingredient for the treatment of cardiovascular disorders and all kinds of pain (Sun et al., 2002).

In view of its large market in Asian countries as well as keen interest in the use and modernization of herbal products throughout the world, this article provides an overview of chemistry, pharmacology and pharmacokinetics of Chuanxiong Rhizoma.

PLANT STUDIES

Chuanxiong Rhizoma (Figure 1) is the dried root of *Ligusticum chuanxiong* Hort. (Figure 2) which enjoys the warm and moist environment, fears the high temperature but can endure severe cold weather and get through the winter in the farmland. As a naturally occurring medicinal herb, the geographical region of its growth and the season of its harvest vary in the active components of Chuanxiong Rhizoma. Sichuan province, China, has been traditionally recognized as the authentic and superior

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Figure 1. Chuanxiong Rhizoma (<http://www.huilinnatural.com/cn/productshow.asp?keyno=3>).



Figure 2. Plant of *L. chuanxiong* Hort.

plant source for the herbal Chuanxiong Rhizoma with a suitable harvest time from April to the end of May depending upon the commercial interest of herbal producers or herbal pharmaceutical manufacturers (Li et al., 2006).

CHEMICAL STUDIES

Main chemical constituents

The main constituents of Chuanxiong Rhizoma oil are phthalides and terpenes. Phthalides such as Z-ligustilide, senkyunolide, neocnidilide, 3-n-butylphthalide, butylidenephthalide and E-ligustilide. Terpenes include p-cymene, g-terpinene, terpinolene, terpinen-4-ol, α -cedrene, β -selinene, α -selinene and spathulenol. These principal compounds from Chuanxiong Rhizoma oil were

identified and quantified under supercritical fluid extraction in gas chromatography-mass spectrometry (GC-MS) (Zhang et al., 2006). For a long time, the aerial parts of *L. chuanxiong* Hort. were discarded as waste when harvested. In the aerial parts of *L. chuanxiong* Hort., forty-six components which make up 85.82% of the total oil were identified by means of GC-MS and GC under steam distillation extraction (Guo et al., 1993). There was no difference in the composition of Chuanxiong Rhizoma oil except the proportion of it, so the aerial parts of *L. chuanxiong* Hort. have a good prospect.

The different packing and storage life will affect the content of active components in Chuanxiong Rhizoma, guiding the moist, volatile oil and ferulic acid in Chuanxiong Rhizoma from two good agriculture practice base by the related determination method in the supplement of Chinese Pharmacopeia (2005). The content of total alkaloids was determined by acid dye colorimetry. The loss of active component in Chuanxiong Rhizoma was the least when in vacuum packing, sack and weave packet. During storage, the content of moist and volatile oil decreased; the content of ferulic acid increased; the content variety of total alkaloids had no regulation. Therefore, the packing of Chuanxiong Rhizoma should choose the sack and weave packet. If the quantity is small, vacuum packing should be used. Combined with the changes of Chuanxiong Rhizoma active component and the phenomenon of mildew and worm eaten during storage, it should not be stored for a long time (Jiang et al., 2005). The distilled fluid of Chuanxiong Rhizoma should be preserved at low temperature under shady place, kept at pH of 5 to secure its quality and clinical effects (Tian et al., 2003). The Chuanxiong Rhizoma oil content of processed products has been reduced in different degrees when compared with raw drug, the content of volatile oil: raw drug > alcohol-broiled product > vinegar processed product > fry yellow product > sample baked with boiled wine (Zhang et al., 1998). As the special smell oily and unstable substance, it can be included in β -cyclodextrin to improve the stability in normal situation, avoiding the loss of active ingredient (Li et al., 2005).

Comparison of different extraction process of Chuanxiong Rhizoma oil

The extractions of Chuanxiong Rhizoma oil include steam distillation extraction, supercritical fluid extraction (SFE), organic solvent extraction and the new method, headspace solid phase micro-extraction (HS-SPME). Different extractions will vary the yield of the volatile oil of Chuanxiong Rhizoma. Steam distillation extraction is a conventional method which has been used frequently to extract the volatile oil from Chuanxiong Rhizoma in the past. But it requires lot of time and the yield of volatile oil

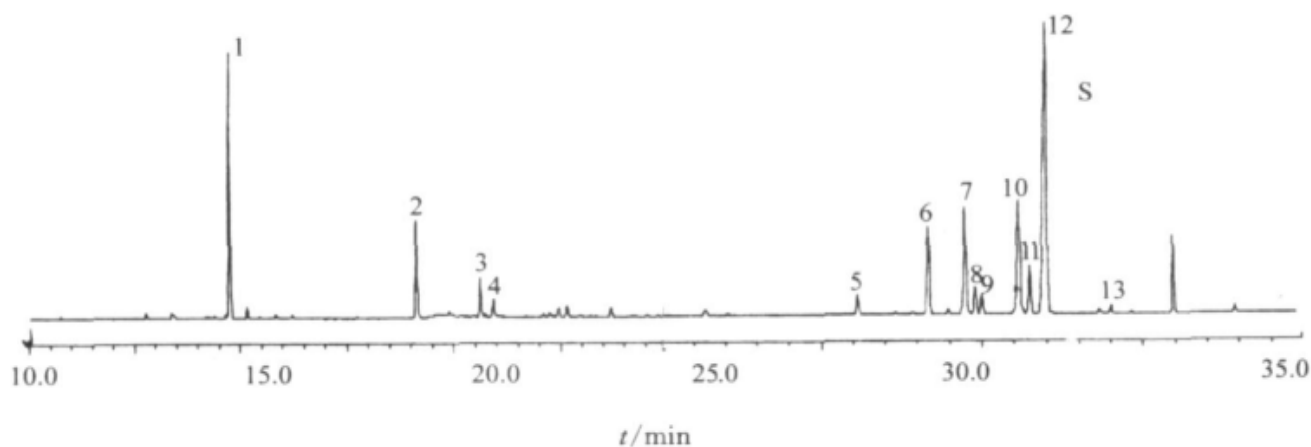


Figure 3. Total ion current chromatogram of essential oil in Chuanxiong Rhizoma.

et al. (2002) identified about 44 compounds from Chuanxiong Rhizoma and the yield of volatile oil is 4.16% (v/w). In contrast, 30 compounds were determined by steam distillation extraction and the yield of volatile oil by steam distillation extraction is 0.8% (v/w) (Hong et al., 2002). Although, both techniques including steam distillation extraction and supercritical fluid extraction, could extract the main components of volatile oil. The contained components of samples extracted by supercritical fluid CO₂ extraction were most and the whole operation process took short time and had high efficiency (Wang et al., 2009). They thought, since SFE is operated at high pressure and lower temperature, compounds with thermo unstable or high volatility would probably have better solubility in supercritical fluid.

Wan et al. (2003) used steam distillation extraction, supercritical fluid extraction and organic solvent extraction to extract essential oil of Chuanxiong Rhizoma. The three methods are able to extract main lactones of volatile oil. Organic solvent extraction can extract fatty acids and fatty acid ester which accounted for 30% of its extracted substance, except for lactone and terpene type, because neutral ethanol is one of the polar organic solvent. Oleic acid can only be obtained by organic solvent extraction (Wan et al., 2003).

HS-SPME was the first high concentration capacity-headspace sampling technique to appear. It was introduced by Zhang and Pawliszyn (1993) as an extension of SPME, which had been developed by Arthur and Pawliszyn (1990) to overcome some drawbacks of solid phase extraction in sampling organic pollutants from water. In recent years, HS-SPME has gained wide acceptance as an effective extraction technique for a wide variety of samples. This method followed by GC-MS is described for the analysis of volatile compounds in the dry rhizome of *L. chuanxiong* Hort.. As a result, 73 compounds were determined and identified by the HS-SPME-GC-MS method with at least 20 more compounds

than those in the methods available. Using much less sample amount, shorter extraction time and simpler procedure, HS-SPME method can achieve similar results to those by steam distillation. The HS-SPME method is simple, rapid and effective and can be used for the analysis of volatile compounds in medicinal plants (Zhang et al., 2007).

Chemical fingerprint

As the complexity of Chinese medicine herbs, many factors can influence the bioactive ingredients of the plants which will vary the therapeutic outcome. Therefore, the quality control is vital to Chinese medicine herbs. The characteristic fingerprint (Figure 3 and Table 1) of Chuanxiong Rhizoma volatile oil has been established to scientifically evaluate and effectively control the inner quality of Chuanxiong Rhizoma, and the quality information has been provided by GC-MS method, using the twelfth (ligusticum) peak as reference (Shi et al., 2007).

PHARMACOLOGICAL EFFECTS

Anti-fibrosis effects

Hepatic fibrosis is due to diseases, such as chronic hepatitis and alcoholic liver disease (Hui and Friedman, 2003). Compounds that promote apoptosis in hepatic stellate cells which play a central role in both fibrogenesis and fibrolysis may have anti-fibrotic potential. Chuanxiong Rhizoma has been found to have the ability of anti-proliferative and pro-apoptotic effects on hepatic stellate cells (HSC), and the pathways mediated by Fas and Bcl2 were involved in herb-induced apoptosis in HSC-T6 (Chor et al., 2005). Two isomeric compounds,

Table 1. Identification of main peaks in essential oil of Chuanxiong Rhizoma.

Peak No.	Name	Relative peak area	Relative retention time
1	terpilenol	0.0637	0.4758
2	2-methoxyl-4-vinylphenol	0.0255	0.6167
3	1-phenyl-1-pentanone)	0.0095	0.6650
4	2,2-dimethyl-1-phenyl,3-butene-1-ketone	0.0051	0.6746
5	spainulenol	0.0423	0.9053
6	butylphthalide	0.1975	0.9409
7	butylidenephthalide	0.2435	0.9592
8	unidentified	0.0566	0.9642
9	cnidilide	0.0421	0.9674
10	east ligustilide	0.3287	0.9862
11	neocindilide	0.1073	0.9914
12	ligusticum	1.0000	1.0000
13	isomer of ligusticum	0.0134	1.0320

ZZ-6,8',7,3'-diligustilide and levistolide A which are the main compounds of volatile oil were identified to be active components against hepatic fibrosis, and they did not decrease the viability after 48 h incubation in both HSC-T6 and LI-90 cells. The mechanism of the two compounds is to inhibit platelet derived growth factor-activated HSC proliferation, possibly through cell cycle inhibition and apoptosis (Lee et al., 2007).

Vasorelaxing effects

Ligustilide and senkyunolide A, two main constituents of Chuanxiong Rhizoma oil, had similar relaxation potencies against contractions to 9,11-dideoxy-9 α , 11 α -methanoepoxyprostaglandin F_{2 α} , phenylephrine, 5-hydroxytryptamine and KCl. Their vasorelaxation effects were not affected by endothelium removal, the adenylate cyclase inhibitor 9-(tetrahydro-2-furanyl)-9H-purin-6-amine, the soluble guanylate cyclase inhibitor 1H-[1,2,4]oxadiazolo[4,3- α]quinoxalin-1-one or the non-selective K⁺ channel blocker tetraethylammonium (Chan et al., 2006). By using cell membrane chromatography (CMC) and GC-MS, Liang et al. (2005) found out that ligustilide and butylidenephthalide significantly inhibited the vasoconstrictions induced by norepinephrine (NE) bitartrate and calcium chloride (CaCl₂) in a concentration-dependent manner (Liang et al., 2005). The mechanism of ligustilide is to induce vasodilatation in rat mesenteric artery by inhibiting the voltage-dependent calcium channel and receptor-operated calcium channel, and receptor-mediated Ca²⁺ influx and release (Cao et al., 2006). Butylidenephthalide-mediated vasorelaxation comprises of both endothelium-dependent and independent components, and it is acting through an inhibitory mechanism downstream to L-type voltage-operated and prostanoid TP receptor-operated Ca²⁺ channels operating late in the contractile pathway (Chan

et al., 2006). Butylidenephthalide has also been found as a synergism with NO donor sodium nitroprusside (SNP) in relaxing rat isolated aorta. The interaction is related to an enhancement of the effectiveness of SNP in producing relaxation under tone induced mainly by Ca²⁺ sensitization (Chan et al., 2009). This finding may serve as the rationale behind the frequent use of a Chuanxiong Rhizoma-NO donor combination in China.

Protective effects

The extract of Fo Shou San including Chuanxiong Rhizoma and Angelicae Sinensis Radix dose-dependently and time-dependently protected human umbilical vein endothelial cells against hydrogen peroxide damage and suppressed the production of reactive oxygen species (Hou et al., 2004). Essential oil of Chuanxiong Rhizoma is able to inhibit DNA damage induced by ultraviolet B via their antioxidant activities through the methods of 1,1-diphenyl-2-picrylhydrazyl (DPPH) and 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS) scavenging assay. In this assay, the essential oils showed very high activity in the DPPH test with an IC₅₀ value of 6.79 mg/ml in Chuanxiong Rhizoma. In addition, the essential oils in ABTS test exhibited an IC₅₀ value of 1.58 mg/ml in Chuanxiong Rhizoma. The mechanism for antioxidants is to remove free radical that involves the donation of hydrogen to a free radical, and hence, its reduction to an unreactive species through removing the odd electron feature which is responsible for radical reactivity (Jeong et al., 2009).

Z-Ligustilide has significant neuroprotective effects on transient forebrain ischemia in mice; focal cerebral ischemia and chronic cerebral hypoperfusion in rats may through antioxidant, improved cholinergic activity and antiapoptotic mechanisms (Kuang et al., 2006; Peng et

Table 2. Pharmacokinetic parameters of senkyunolide A in rats after i.v., i.p. and p.o. administration (n =5, Mean \pm S.D.).

Pharmacokinetic parameter	Route of administration				
	i.v.		i.p.		p.o.
Dose (mg/kg)	20 (pure)	7.65 (ext) [†]	50	100	100
T _{max} (h)	-	-	0.04 \pm 0.01	0.04 \pm 0.01	0.21 \pm 0.08***
C _{max} (mg/L)	19.67 \pm 3.48	4.86 \pm 0.45	17.60 \pm 3.35	31.01 \pm 4.26	1.66 \pm 0.23***
t _{1/2} (h)	0.65 \pm 0.06	0.69 \pm 0.31	0.67 \pm 0.10	0.99 \pm 0.23	0.52 \pm 0.03
AUC _{0-∞} (mg·h/L)	2.81 \pm 0.19	0.95 \pm 0.16	5.29 \pm 0.94	10.65 \pm 0.98	1.11 \pm 10***
V _d /F (l/kg)	6.74 \pm 0.73	7.12 \pm 2.16	9.98 \pm 1.66	13.78 \pm 3.30	68.97 \pm 4.64***
CL/F (l/h/kg)	7.20 \pm 0.48	9.17 \pm 1.81	10.92 \pm 2.10	9.72 \pm 0.91	94.81 \pm 12.06***
F (%)	-	45.7	75.3	75.8	7.9***

***P < 0.001 compared with the same intraperitoneal doses. [†]The herbal extract containing 7.65% of senkyunolide A was given at a doses of 100 mg/kg.

al., 2007; Kuang et al., 2008). It was also pronounced that Z-Ligustilide has a protective effect against H₂O₂-induced cytotoxicity, at least partly through improving cellular antioxidant defense and inhibiting the mitochondrial apoptotic pathway (Yu et al., 2008).

Antipyretic effects

The activity of body temperature regulation was involved by central monoamine neurotransmitters. The theory of monoamine of body temperature recognized that the quantity dynamic balance of 5-hydroxytryptamine (5-HT) and norepinephrine (NE) can keep a relative constancy of body temperature. The report showed that the essential oil of Chuanxiong Rhizoma have the ability of antipyretic effect and make the proportion of 5-HT and NE in hypothalamus have a significant change, so it was considered as one of the mechanism of Chuanxiong Rhizoma to antipyretic effect (Li et al., 2003b).

Anti-trichophyton effects

At present, trichophyton are frequently treated by oral administration of ketoconazole or the development drug. However, ketoconazole have unpleasant side effects and the other drug has relatively low bioavailability after oral administration and adverse effects. Ligustilide and butylidenephthalide, which are major oil components comprising of the volatile oil of Chuanxiong Rhizoma, have the synergistic anti-fungal effects in combination with antifungal drugs by checkerboard microtiter and microdilution tests. With this synergistic anti-fungal effect, the use of lower concentrations of ketoconazole may facilitate and minimize its potential side effects. The improvement of anti-trichophyton activity of itraconazole administered in combination with ligustilide or butylidenephthalide could provide alternative therapies to overcome current limitations in the use of itraconazole for treatment of trichophyton infections (Sim and Shin, 2008).

PHARMACOKINETICS

In recent years, with the development of analytical technique, many investigations have been reported the pharmacokinetics of Chuanxiong Rhizoma oil. However, these reports were concentrated on senkyunolide A, ligustilide and butylidenephthalide, the other compounds of essential oil of Chuanxiong Rhizoma are very limited. The main pharmacokinetics of these three active components is summarized as the following.

Senkyunolide A

The pharmacokinetic parameters of senkyunolide A after three different ways of administration, including intravenous (i.v.), intraperitoneal (i.p.) and per os (p.o.) are as shown in Table 2. After i.v. administration, senkyunolide A was extensively distributed [apparent volume of distribution based on the terminal phase (V_d/F): 6.74 \pm 0.73 l/kg] and rapidly eliminated from the plasma [apparent plasma clearance (CL/F): 7.20 \pm 0.48 l/h/kg and biological half life (t_{1/2}): 0.65 \pm 0.06 h]. Hepatic metabolism was suggested as the major route of senkyunolide A elimination as indicated by the results of *in vitro* S9 fraction study. After i.p. administration, senkyunolide A exhibited dose-independent pharmacokinetics. The absorption after i.p. administration was rapid [maximum concentration (T_{max}): 0.04 \pm 0.01 h], and the absolute bioavailability (F) was 75%. After p.o. administration, senkyunolide A was also absorbed rapidly (T_{max}: 0.21 \pm 0.08 h); however, its oral bioavailability was low (~8%). The contributing factors were determined to be instability in the gastrointestinal tract (accounting for 67% of the loss) and hepatic first-pass metabolism (accounting for another 25%). Pharmacokinetics of senkyunolide A were unaltered when Chuanxiong Rhizoma extract was administered, which suggests that components in the extract have insignificant effects on

Table 3. Pharmacokinetic parameters of ligustilide in rats after i.v., i.p. and p.o. administration (n=5, Mean \pm S.D.).

Pharmacokinetic parameter	Route of administration				
	i.v.		i.p.		p.o.
Dose (mg/kg)	15.6	14.9 ^a	26	52	500
T _{max} (h)	-	-	0.05 \pm 0.02	0.08 \pm 0.01	0.36 \pm 0.19
C _{max} (mg/L)	13.19 \pm 0.84	6.93 \pm 0.60 ^{***}	7.48 \pm 1.10 ^{***}	20.75 \pm 2.55 ^{###}	0.66 \pm 0.23 ^{***}
t _{1/2} (h)	0.31 \pm 0.12	0.22 \pm 0.07	0.36 \pm 0.05	0.44 \pm 0.08 [#]	3.43 \pm 1.01 ^{***}
AUC _{0-∞} (mg·h/L) ^b	1.81 \pm 0.24	0.79 \pm 0.10 ^{**}	0.93 \pm 0.07 [*]	1.77 \pm 0.23 [#]	0.047 \pm 0.012 ^{**}
V _d /F (l/kg) ^c	3.76 \pm 1.23	5.62 \pm 1.19	6.54 \pm 1.56	6.32 \pm 1.81	1641.9 \pm 121.6 ^{***}
CL/F (l/h/kg) ^c	9.14 \pm 1.27	20.35 \pm 3.05 ^{**}	16.9 \pm 1.21 ^{**}	9.26 \pm 1.04 ^{##}	411.1 \pm 145.7 ^{***}
MRT (h)	0.3 \pm 0.07	0.19 \pm 0.03	0.3 \pm 0.05	0.41 \pm 0.03	5.14 \pm 1.56 ^{***}
F (%)	-	45.7 ^d	51.7	97.7	2.6

*P < 0.05, **P < 0.01, ***P < 0.001, compared with i.v. dosing of the isolated ligustilide. [#]P < 0.05, ^{##}P < 0.01, ^{###}P < 0.001, compared with the lower i.p. dose of the isolated ligustilide. ^aDose of ligustilide in 100 mg/kg of Chuanxiong Rhizoma extract. ^bNormalized with dose. ^cData represent V_d and CL in the case of i.v. dosing of the isolated ligustilide. ^dRelative bioavailability compared with that of i.v. dosing of the isolated ligustilide.

senkyunolide A pharmacokinetics (Yan et al., 2007).

Ligustilide

The pharmacokinetic parameters of ligustilide after three different administrations, including i.v., i.p. and p.o. are as shown in Table 3. After i.v. administration of pure ligustilide, it was distributed extensively (V_d/F: 3.76 \pm 1.23 l/kg) and eliminated rapidly (t_{1/2}: 0.31 \pm 0.12 h). The i.v. CL/F of ligustilide after Chuanxiong extract administration was significantly higher than that dosed in its pure form [CL/F: 20.35 \pm 3.05 versus 9.14 \pm 1.27 l/h/kg, P<0.01; area under the plasma concentration-time curve from time 0 to time infinity (AUC_{0-∞}): 0.79 \pm 0.10 versus 1.81 \pm 0.24 mg·h/l, P<0.01] suggesting significant interaction between ligustilide and components present in the extract. Dose-dependent pharmacokinetics was observed after i.p. administration, and a significantly higher dose-normalized AUC_{0-∞} (1.77 \pm 0.23 mg·h/L) at 52 mg/kg was obtained than that at 26 mg/kg (0.93 \pm 0.07 mg·h/L, P<0.05). Oral bioavailability of ligustilide was low (2.6%), which was partly because of extensive first-pass metabolism in the liver (Yan et al., 2008).

The order of distribution of ligustilide in the main effector organs are as follows: C_{lung} > C_{heart} > C_{brain}, and distributions in the main eliminator organs were as follows: C_{liver} > C_{spleen} > C_{kidney}. The concentration of ligustilide in tissues in different time is as shown in Figure 4 (Qian et al., 2008). There is a difference in the metabolism of the main active constituent monomer and the active constituent group. High-performance liquid chromatography with diode array detection was used to analyze the metabolites in the urine, feces and bile of rats dosed with the essential oil or ligustilide. A clear difference in the metabolism of the essential oil and ligustilide indicating that the multiple components of essential oil influence the types of metabolites produced

and the relative ratios of the main active components. The possible pathway for the metabolism of ligustilide in rats is as shown in Figure 5 (Ding et al., 2008).

Butylidenephthalide

Butylidenephthalide quickly permeate into peripheral circulation system without accumulation in the skin and then distribute into lung, liver, bile and kidney after dermal application by the whole body autoradiogram and liquid scintillation analysis, and excretion mainly into urine. In the case of i.v. administration, 80% of the administered butylidenephthalide was excreted into urine within 24 h, while only 5% was excreted into feces within 24 h. The metabolite in urine was determined to be a cysteine conjugate by LC-MS/MS method (Sekiya et al., 2000).

TOXICITY STUDIES

L. chuanxiong Hort., which is contained in China plant map database is one of the poisonous plant. The acute toxicity (LD₅₀) was 328 mg/kg in mice when the essential oil of radix and stem of *L. chuanxiong* Hort. was administered by intraperitoneal injection resulting in death within 4 to 5 h.

Using toxic effect method to detect pharmacokinetic parameter of Chuanxiong Rhizoma oil, LD₅₀ was 517.51 \pm 90.01 mg/kg and 2982.37 \pm 345.12 mg/kg after the administration to mice by i.p. and i.g., respectively (Pan et al., 1999).

CONCLUSION

L. chuanxiong Hort., as one of the TCM herbs has been used clinically for thousands of years in China. In the

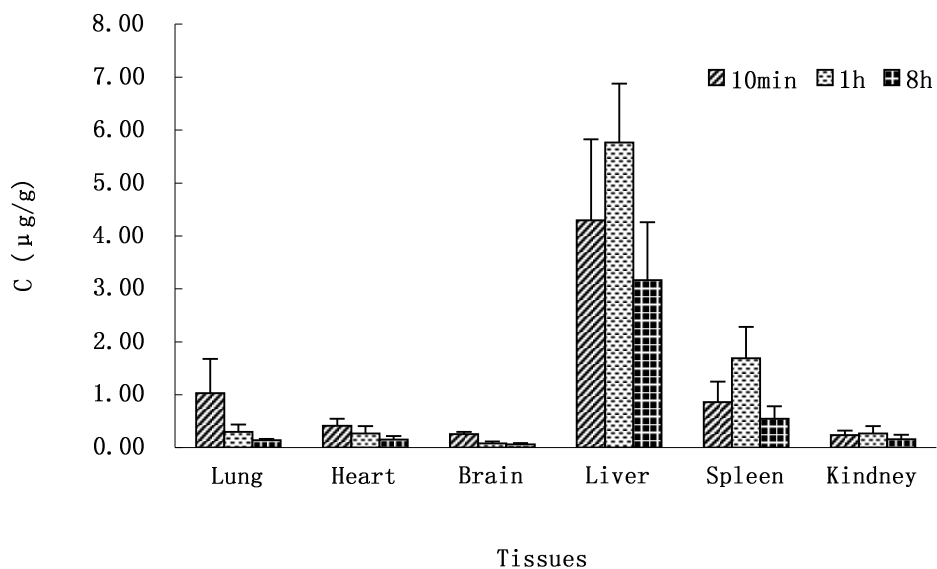


Figure 4. Concentration of ligustilide in tissues in different time (n=12, Mean \pm Standard deviation).

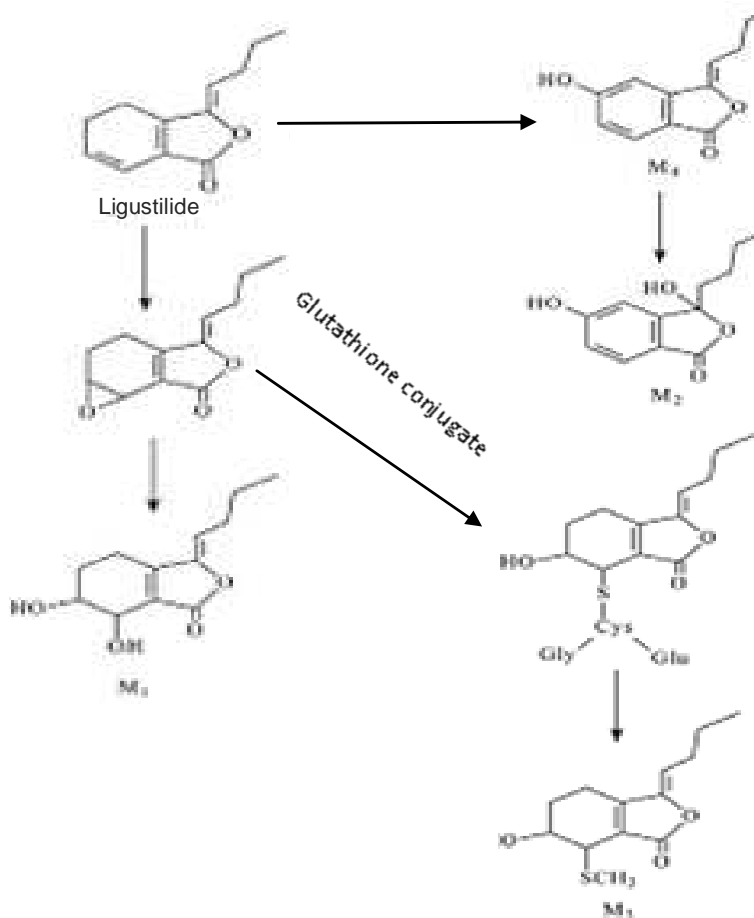


Figure 5. Proposed metabolic pathway of ligustilide in the rat. Gly, glycine; Cys, cysteine; Glu, glutamate.

active component study, many investigations suggested that alkaloids (tetramethylpyrazine), phenolic acids (ferulic acid) and volatile oils (ligustilide and senkyunolide A), especially tetramethylpyrazine are considered as the main factor to the effect of blood circulation. However, the quantities of tetramethylpyrazine and ferulic acid in raw Chuanxiong Rhizoma were lower (<0.0001 and < 1%, respectively) (Yan et al., 2005; Li et al., 2003a) compared with volatile oil and ferulic acid present in numerous plant species. Senkyunolide A and ligustilide belonging to volatile oil of Chuanxiong Rhizoma may be the active components as they accounted for considerable proportion of it (Chan et al., 2007; Liang et al., 2005). In the part of anti-fibrillation, vasorelaxation, protection and antipyretic, volatile oil of Chuanxiong Rhizoma has a good effect, and it can improve anti-trichophyton and vasorelaxation combined with other drugs. The absorption of Chuanxiong Rhizoma oil is rapid but the bioavailability is very low by oral administration. Although, pharmacologic action of Chuanxiong Rhizoma oil has been confirmed, little work has been done to the instability of volatile oil and its active constituents under room temperature and processing in the extraction, while the pharmacokinetic studies mostly focused on animals. Thus, future studies should aim at the characterization of pharmacokinetic on human subjects and improving the stability and oral bioavailability of Chuanxiong Rhizoma oil in order to illustrate the mechanism of its action and improve rationality of the utilization of Chuanxiong Rhizoma in clinical practice.

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