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Pharmaceutical Biology

ISSN: 1388-0209 (Print) 1744-5116 (Online) Journal homepage: https://www.tandfonline.com/loi/iphb20

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To cite this article: Li Yang & Jian-Guo Jiang (2009) Bioactive components and functional properties of *Hottuynia cordata* and its applications, Pharmaceutical Biology, 47:12, 1154-1161, DOI: 10.3109/13880200903019200

To link to this article: https://doi.org/10.3109/13880200903019200

Published online: 16 Nov 2009.

Pharmaceutical Biology, 2009; 47(12): 1154–1161

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REVIEW ARTICLE

Bioactive components and functional properties of *Hottuynia cordata* and its applications

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Abstract

Houttuynia cordata Thunb. is a member of Saururaceae, a family mainly distributed in Eastern Asia. It has long been used in China both as an edible vegetable and in traditional medicine. Recent studies indicate that *H. cordata* contains abundant nutrients and active components including volatile oils, flavonoids, and water soluble polysaccharides. In addition, *H. cordata* exhibits a wide range of pharmaceutical activities including antibacterial, antiviral, anti-inflammatory, immunologic, anticancer, antioxidative, and antimutagenic effects. At present, injectable *H. cordata* has been used clinically for treating infectious disease, inflammation, and anaphylaxis. This paper provides a comprehensive review of the nutrients and pharmacologically relevant compounds of *H. cordata* that have been characterized to date, and of the studies supporting its medicinal use. Particular attention has been given to the pharmacological action and the state of utilization of *H. cordata*. Finally, future trends on *H. cordata* such as pharmacological components and mechanism, and the development of potential products have briefly been inferred.

Keywords: *Bioactive components;* Houttuynia cordata*; nutritional ingredients; pharmacological action*

Introduction

The Saururaceae family contains four genera and six species. *Houttuynia cordata* Thunb. (*H. cordata*), a perennial herb, is the sole member of the genus *Houttuynia* (Liang, 1995). *H. cordata* reaches an average length of 15- 50 cm, and has a thin stalk and heart-shaped leaf. It is usually harvested in summer or autumn when its stalk and leaves mature. It is distributed mainly in Eastern Asia. Within China, it occurs mainly in the central, southeast and southwest regions (Yang, 2003).

H. cordata contains a number of mineral nutrients (essential to the human body) as well as other active components – specifically, high levels of volatile oils and flavonoids (Zheng & Li, 2002). The Chinese Ministry of Health included it the list of medicine and food in 1998 (Li, 2001). Since ancient times, *H. cordata* has been used in China as an edible vegetable and effective traditional Chinese medicine (TCM). It has a wide range of benefits including an antileukemic effect (Kwon et al., 2003), antimutagenic effect (Chen et al., 2003), anti-inflammatory action (Chiang et al., 2003), and antianaphylaxis effect (Li et al., 2005), as well as the ability to promote immunologic function. Hayashi et al. (1995) reported on its antileukemic activity and virucidal effects on the human immunodeficiency virus (HIV).

In China, the Science and Technology Group of the National Headquarters for SARS Prevention and Control was set up on April 25, 2003. On May 23, 2003, Chinese scientists affirmed eight types of traditional Chinese medicine that had been shown to play a role in reducing the side-effects of western medicine and improving the immune systems of patients infected with severe acute respiratory syndrome (SARS). The eight, including injections of *H. cordata*, were found effective in curbing lung inflammation. In addition, *H. cordata* reduced fever, chills, headaches, muscular pain, malaise, diarrhea, and dry tight coughs (Lu et al., 2006b).

More recently, *H. cordata* has become a candidate for treating SARS in China since preliminary experimental results indicated that *H. cordata* extracts can kill the SARS virus (Xu et al., 2005). Currently, *H. cordata* is used

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(Received 14 February 2008; revised 20 August 2008; accepted 21 September 2008)

ISSN 1388-0209 print/ISSN 1744-5116 online © 2009 Informa UK Ltd
DOI: 10.3109/13880200903019200
http://www.informahealthcare.com/phb

in clinical therapy as TCM to treat infectious disease, inflammation, and anaphylaxis. In order to fully utilize this widely available herb in areas such as the food and cosmetic industries, this review summarizes the progress of studies on the nutritional ingredients, active components, pharmacological actions, and the utilization of *H. cordata*.

Nutritional ingredients of *H. cordata*

Recently, research on the analysis of the nutrients in *H. cordata*, has reported amino acids, vitamins and trace elements such as potassium, zinc, iron, copper and manganese (Tables 1 and 2). The reported quantity of these elements varies depending on the harvesting season, cultivars, growing conditions and test facilities.

At least sixteen amino acids were found in *H. cordata*, of which six are essential amino acids. Zinc, iron, copper, and manganese as essential trace elements have an important physiologic function. So the herb is rich in nutritional ingredients which are conducive to health.

Active components in H. cordata

Medicinal plants typically contain several different bioactive compounds that may act individually, additively or in synergy to improve health (Gurib-Fakim, 2006). In recent decades, active components isolated from botanical sources have attracted great attention in the biomedical area because of their high effectiveness and low toxicity (Ren et al., 2004). Those found in *H. cordata* include volatile oils (decanoyl acetaldehyde, myrcene, lauric aldehyde, α-pinene, D-limonene, methyl nonyl ketone), organic acids (palmitic acid, linoleic acid, aspartic acid), flavonoids (quercetin, isoquercitrin, afzelin, hyperin, reyoutrin, rutin), cordarine, kalium sulfuricum, water-soluble polysaccharides (Li et al., 2004; Chen et al., 2004; Cao & Wang, 2005).

Volatile oils

Volatile oils represent a small fraction of the composition of medicinal plants, but have a wide distribution in the vegetable kingdom. They exhibit a wide range of pharmaceutical activities such as anaphylaxis (Tanaka et al., 1996), enzyme inhibiting (Miyazawa et al., 1997), antimutagenic (Miyazawa et al., 1996), antimicrobial (Barmba et al., 1993), antiviral (EI-TE et al., 1994), insecticidal (Sharma et al., 1992), and a depressant activity on the central nervous system (Ansari et al., 1993). Chen et al. (2005) reported that the volatile oils content of *H. cordata* originating from different collections, from wild and cultivated plants as well as from different regions (root, stalk, and leaf), ranged from 0.038 to 0.16 (mL/g). A main component in volatile oils, decanoyl acetaldehyde, has known pharmacological effects, but it is unstable and easily oxidized (Figure 1) (Zeng et al., 2003) during distillation and storage. Thus, it is crucial that the natural proportion of the components is maintained during extraction of the essence (Table 3). Liang et al. (2005) compared three procedures (HS-SPME, FE and SD for

Table 2. The contents of amino acids of *H. cordata* (Wu et al., 2000).

Component	Content
Threonine (Thr)	0.644%
Valine (Val)	0.772%
Methionine (Met)	0.142%
Leucine (Leu)	0.968%
Lysine (Lys)	0.629%
Isoleucine (Ile)	0.604%
Phenylalanine (Phe)	0.660%
Glutamic acid (Glu)	0.933%
Serine (Ser)	0.261%
Histidine (His)	0.460%
Arginine (Arg)	0.719%
Glycine (Gly)	0.691%
Proline (Pro)	0.728%
Alanine (Ala)	0.729%
Tyrosine (Ala)	0.422%
Aspartic acid (Asp)	1.717%

Table 1. Chemical components and contents of *H. cordata.*

Component	Content	References
Water	84.67~86.53 g/100 g	Fu et al., 2006; Qi et al., 2001
Crude protein	2.01~5.26 g/100 g	Qi et al., 2001; Cao & Wang., 2005; Ren et al., 1998
Crude fat	0.3~2.41 g/100 g	Qi et al., 2001; Fu et al., 2006; Ren et al., 1998
Total sugar	1.6~6 g/100 g	Qi et al., 2001; Chen, 2002
Vitamin C	68.47~83.57 mg/100 g	Han, 2003; Qi et al., 2001
β-Carotene	2.59~3.45 mg/100 g	Cao & Wang., 2005; Han, 2003
Potassium	718.1 mg/100 g	Han, 2003
Iron	9.795~12.6 mg/100 g	Han, 2003; Ren et al., 1998
Zinc	56.3 ug/100 g	Xiao et al., 2003
Copper	15.5 ug/100 g	Xiao et al., 2003
Manganese	58.8 ug/100 g	Xiao et al., 2003
Phosphonium	38.27~53 mg/100 g	Han, 2003; Ren et al., 1998; Chen, 2002

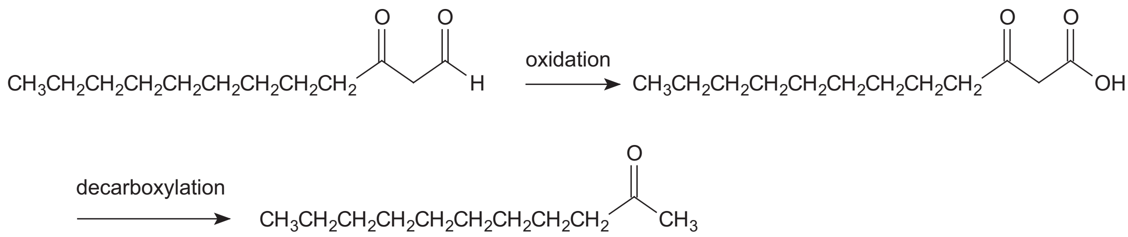

Figure 1. The decanoyl acetaldehyde can be converted into 2-undecanone via both oxidation and decarboxylation.

Table 3. Summary of main extraction techniques of volatile compounds from *H. cordata*.

Extraction technique	Advantage	Disadvantage	Reference
Steam distillation (SD)	A traditional method	Requires a large amount of sample; time-consuming; destroys heat-sensitive compounds.	(Illes et al., 2000)
Solid-phase microextraction (SPME)	A solvent-less extraction technique; reduces loss of constituents		(Liang et al., 2005)
Supercritical carbon dioxide extraction	Has relatively low critical pressure and temperature	CO_2 – its lack of polarity for the extraction of polar analytes	(Wang et al., 2003)
Flash evaporation (FE)	No extraction and direct application for the analysis; fewer samples needed	FE method is not sensitive to many volatile component; leads to the oxidation of volatile compounds	(Qi et al., 2004)
Organic solvent extraction	An alternative to conventional process	High pressure; solvent remains	(Eikani et al., 1999)

Gas Chromatography and Mass Spectrometry (GC-MS)) for extraction. He concluded that HS-SPME was the most selective and was particularly efficient in the isolation of volatile oils, obtaining a greater number of compounds than that of FE or SD. A total of 60 compounds were detected in SPME extracts while in FE and SD extracts, the detected compounds were 41 and 51, respectively. The total amount of compounds isolated by SPME was much larger than that isolated by FE or SD.

Flavonoids

Flavonoids are natural products widely distributed in the vegetable kingdom and currently consumed in large amounts (± 1 g) in the daily diet (Carlo et al., 1999). In citrus fruit they may represent up to 1% of the fresh fruit. Flavonoids are capable of modulating the activity of enzymes and affecting the behavior of many cell systems, suggesting that they may possess significant anti-hepatotoxic, antiallergic, anti-inflammatory, anti-osteoporotic and even anti-tumor activity.

Guo and Xu (2007) found that the yield of flavonoids in *H. cordata* reached 0.586%. Flavonoids have been identified as rutin, hypersoide, quercetin and quercitrin using analysis of their physical and chemical properties, Thin Layer Chromatography (TLC) and Ultraviolet-visible detection (UV-VIS). In a recent study, the molecular structures of the rutin, hyperoside, quercitrin and quercetin from flavonoids of *H. cordata* were estimated (Figure 2). The content of the rutin, hyperoside, quercitrin and quercetin was 7.6%, 7.65%, 8.1% and 16.7% respectively. The leaves contained a higher content of the four flavonoids than the roots (Xu et al., 2006). Meng et al. (2006) employed various columns including Diaion HP-20, Sephadex LH-20, ODS and silica gel for the isolation and purification of compounds from fresh *H. cordata*. The structures of the compounds were identified by physiochemical properties and spectral analysis. Five compounds were isolated and identified as (**1**) quercetin-3-*O*-β-D-galactoside-7-*O*-β-D-glucoside, (**2**) kaempferol-3-*O*-α-L-rhamnopyranosyl-(1 →6)-β-D-glucopyranoside, (**3**) quercitrin, (**4**) hyperin, (**5**) quercetin-3-*O*-α-L-rhamnopyranosyl-7-*O*-β-D-glucopyranoside. This was the first time that compounds (**1**), (**2**) and (**5**) were separated from *H. cordata*. In the literature, pressurized liquid extraction (PLE) (Zhang et al., 2007), hot soaking, macroporous exchange resin (You, 2006), and ultrasound-assisted extraction (Li et al., 2006) have all been adopted to extract flavonoids from *H. cordata*.

Water soluble polysaccharides

Polysaccharides from plant, epiphyte and animal extracts are an interesting source of additives, particularly for the food and drug industries (Li et al., 2007). Botanical polysaccharides exhibit a number of beneficial therapeutic properties, and it is thought that the mechanisms involved in these effects are due to the modulation of innate immunity and, more specifically, enhanced an activated macrophage function. This leads to immunomodulation, anti-tumor activity, wound-healing and other therapeutic effects (Schepetkin & Quinn,

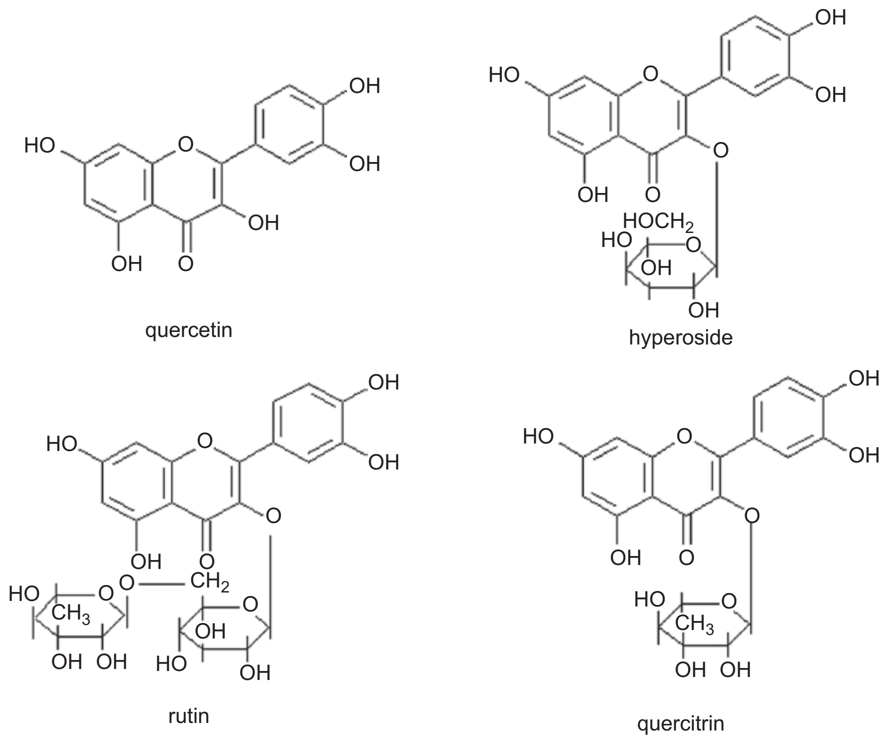

Figure 2. The molecular structures of quercetin, hyperoside, rutin, and quercitrin (modified from Xu et al., 2006).

2006). Zhang et al. (2000) identified the components of water-soluble polysaccharides extracted from *H. cordata* by polyacrylamide gel electrophoresis and thin layer chromatography. They were assessed to be a heteroglycan composed of glucose, fructose, arabinose, galactose, xylose, rhamnose and an unknown pentaglucose. Cheng & Li (2006) found that the polysaccharides of *H. cordata* could quench 50% of hydroxy and superoxide radicals at a concentration of 6 and 6.25 mg/mL respectively. Using conventional extraction technology, the yield of flavonoids and water soluble polysaccharides was relative low (Sheng et al., 1999; Zhang et al., 2000). However, Chen and Cheng (2005) introduced microwave-assisted complex extraction technology by which the extraction yields of all effective constituents and utilization rate of raw materials increased significantly.

Pharmacological action of *H. cordata*

Antibacterial action

A main component in *H. cordata*, decanoyl acetaldehyde, is known to have pharmacological effects. The twofold broth dilution and agar dilution method was used to study all the essential oils of *H. cordata* for their antibacterial properties against *Staphylococcus aureus* and *Sarcina ureae*. The method determined the minimum inhibitory concentration (MIC) of essential oil from different species and parts of species. Results showed that all essential oils possessed antibacterial effect, with MIC values in the range of $0.0625\times10^{(-3)}$ to $4\times10^{(-3)}$ mL/mL (Lu et al., 2006a). Zhou et al. (2006) studied the bacteriostatic action of *H. cordata* by designing a $L^9\,(3^4)$ extraction method, and using, petroleum ether as the solvent, and *Staphylococcus aureus*, *Bacillus dysenteriae*, *Escherichia coli,* yeast, fungus and *Penicillium* as the tested strains. While all parts of the herb exhibit bacteriostatic action, the extract from the root had stronger inhibition on S*taphylococcus aureus*, *Escherichia coli*, and yeast with MIC of 0.04, 0.06, 0.06 g/mL, respectively. The leaf extract had stronger inhibition on *Bacillus dysenteriae*, the MIC was 0.08 g/mL, all extracts had no obvious bacteriostatic action on *Penicillium*. At present, antiseptic drugs extracted from *H. cordata* have been widely used in clinical therapy.

Antiviral activity

H. cordata has an inhibitory action on several viruses. The steam distillate has direct inhibitory activity against herpes simplex virus type 1 (HSV-1), influenza virus, and human immunodeficiency virus type 1 (HIV-1) without showing cytotoxicity, but not against poliovirus and coxsackie-virus. The loss of viral infectivity was related to the duration of drug treatment. Three major components of the distillate, methyl *n*-nonyl ketone, lauryl aldehyde, and capryl aldehyde, also inactivated HSV-1, influenza virus, and HIV-1. The *in vitro* findings demonstrated that the essential oils provide virucidal activity against enveloped viruses by interfering with the function of the virus envelope (Hayashi et al., 1995). Based on the cytopathogenic effect, the extracts from *H. cordata* inhibited the replication of influenza virus A, B, and mumps (IFVA, IFVB, MPV). The lowest antiviral concentration needed for each was 4.5, 2.25 and 14 mg/mL, respectively (Li et al., 1999). Chiang et al. (2003) evaluated the antiviral activity of *H. cordata* using a cytotoxicity test with an XTT-based colorimetric assay. BCC-1/KMC cells were infected with herpes simplex virus (HSV) and then were cultured with a hot water extract of *H. cordata* (HWHC). HWHC significantly inhibited the replication of HSV at a concentration of 250 µg/mL (10.2% for HSV-1, $p < 0.05$; 32.9% for HSV-2, $p < 0.005$). The ED_{50} of HSV type 1 (HSV-1) and HSV type 2 (HSV-2) for HWHCq were 822.4 and 362.5 µg/mL, respectively. Both drugs had selective indexes above 1.04. *H. cordata* was more effective against HSV-2 than against HSV-1, and had a low ED_{50} against HSV-2. This suggests that *H. cordata* might be useful against HSV-2.

Anti-inflammatory action

H. cordata injections (HCI) have been used as an anti-inflammatory in China. In order to validate this property, the inflammation induced by carrageenan in rat pleurisy and by xylene in mouse ear edema was adopted. Injection of carrageenan into the pleural cavity elicited an acute inflammatory response characterized by protein-rich fluid accumulation and leukocyte infiltration in the pleural cavity. The peak inflammatory response was obtained at 24 h when the fluid volume, protein concentration, C-reactive protein, and cell infiltration were the highest. The results showed that these parameters were attenuated by HCI at any dose and touched bottom at a dose of 0.54 mL/100 g. This drug was also effective in inhibiting xylene-induced ear edema, and the percentage of inhibition was 50% at a dose of 80 µL/20 g. These results confirm that HCI has anti-inflammatory activity (Lu et al., 2006b).

Synthetic houttuynin also showed a marked suppressive effect on the mouse ear edema induced by croton oil and the rat hind paw edema induced by carrageenan. It was also found to inhibit vascular permeability induced by acetic acid in mice. In addition, a significant analgesic effect was observed on inflammatory pain caused by acetic acid, formaldehyde and heat stimulus (Li et al., 1998).

Immunologic function

Feeding decanoyl acetaldehyde to induced splenectomy immunodeficiency mice strengthened the phagocytosing function of the peritoneal macrophage system, delayed the typical hypersensitivity (DTH) reaction, and significantly enhanced the level of serum hemolysin and the ANAE (+) cell percentage of the peripheral blood lymphocytes. These results suggest that decanoyl acetaldehyde can strengthen non-specific and specific immune functions in splenectomized mice (Shao et al., 1999).

Antioxidative and antimutagenic effect

Chen et al. (2003) evaluated the antioxidative effect of *H. cordata* by subjecting rodents to oxidized frying oil-induced oxidative stress to examine the antimutagenic effects of *H. cordata* using the Ames test. Forty-eight Sprague-Dawley rats were fed a diet of 0%, 2%, or 5% of *H. cordata* and 15% fresh oil or oxidized frying oil (OFO) for 28 days. Levels of polyphenol in the feces, plasma, and liver were determined. The LDL lag time, plasma total antioxidant status (TAS), and levels of thiobarbituric acid-reactive substances (TBARS) were used as antioxidative indices, and the protein carbonyl group was used as an oxidative index. Results showed that the polyphenol content decreased in the plasma and increased in the feces when administering OFO, and the apparent absorption of polyphenol also decreased while the polyphenol content in plasma increased. There was a higher polyphenol concentration in the water extracts of *H. cordata* than in its methanol extracts. The OFO-fed groups had higher plasma TBARS and hepatic protein carbonyl group concentrations and shorter LDL lag times than those of the control group. The total TAS was elevated and the LDL lag time was prolonged when fed with *H. Cordata*. In addition, both water and methanol extracts of *H. cordata* had an antimutagenic effect on benzo(*a*)pyrene, aflatoxin B_1, and OFO, and showed a dose-dependent response using the Ames test. In conclusion, the polyphenol in *H. cordata* was easily absorbed and metabolized by rodents. *H. cordata* showed both antioxidative and antimutagenic properties under OFO feeding-induced oxidative stress.

Anticancer effect

Kwon et al. (2003) investigated the cellular effects of *H. cordata* extract (HCE) and the signal pathways of HCE-induced apoptosis on the HL-60 human promyelocytic leukemia cell line. HCE treatment caused apoptosis of cells as evidenced by discontinuous fragmentation of DNA, the loss of mitochondrial membrane potential, release of mitochondrial cytochrome C into the cytosol, activation of procaspase-9 and caspase-3, and proteolytic cleavage of poly (ADP-ribose) polymerase. Pretreatment of Ac-DEVD-CHO, caspase-3 specific inhibitor, or cyclosporin A, a mitochondrial permeability transition inhibitor, completely abolished HCE-induced DNA fragmentation. Together, these results suggest that HCE possibly causes mitochondrial damage leading to cytochrome c release into cytosol and activation of caspases resulting in PARP cleavage and execution of apoptotic cell death in HL-60 cells. To evaluate the anti-leukemic activity of *H. cordata*, cytotoxicity tests with an XTT-based colorimetric assay were used. Five leukemic cell lines, namely L1210, U937, K562, Raji and P3HR1, were cultured with hot water extracts of *H. cordata*. The five lines were inhibited with IC_{50} between 478 and 662 μg/mL (Chang et al., 2001).

Application of *H. cordata*

Fresh herb of H. cordata

China has long kept the most extensive records on the use of *H. cordata* as a wild vegetable. Both the root and herb are edible and highly nutritious. As a supplementary vegetable, it has been increasingly consumed by more and more people. Usually, the herb is eaten raw or to flavor foods such as stewed meat, mixed flour, or cooked gruel to facilitate its use. After studying its practicality as a supplement, Zhou (2006a) studied *H. cordata* as a convenience food, while Zhou (2006b) introduced the processing technology of soft-packing flavored *H. cordata,* which will contribute to its marketing.

The processing of *H. cordata*

In recent years *H. cordata* has been used as a healthy additive in different products.

Utilization of H. cordata *extracts*

H. cordata has abundant nutritional ingredients, including volatile oils, flavonoid and water soluble polysaccharides, etc. which are beneficial if eaten regularly. At present, the extract is used in flavoring in various beverage products, including soft drinks, fermented drinks (Wu & Tang, 2001) and teas (Gong, 2003). Liu and Xue (2006) proposed a composite health beverage made from the extracts of *H. cordata* and kudzuvine root. The best recipe was 40% each of *H. cordata* and kudzuvine root compound juice with 0.6% honey, 0.9% citric acid and 0.04% CMC-Na. Using *H. cordata*, girald acanthopanax bark and Glycyrrhiza uralensis as the main ingredients, Zhang et al. (2005) prepared a recipe for *H. cordata* tea, which had therapeutic effects such as heat-clearing and detoxifying, increasing lung moisture to arrest cough, eliminating rheumatism and strengthening bones and muscles.

Utilization of H. cordata *herb*

Using *H. cordata* as the main ingredient, Zhou (2007) studied processing it as a fried food. The fresh herbs were blanched for 1 min, dried for 120 min at 70°C, then fried for 2 min at 180°C, followed by removing excess oil, seasoning and vacuum packing. The final product retained the characteristic crispness and flavor of *H. cordata*. Furthermore, it was found that the problem of browning and wilting was solved by frying. Using fresh beef and *H. cordata* as the main ingredients, Zhan et al. (2006) studied beef jerky with *H. cordata*, which not only strengthened the flavor of the beef jerky, but added health benefits.

Utilization of H. cordata *volatile oils*

A main component in *H. cordata,* decanoyl acetaldehyde, is known to be antibacterial. Therefore, the extract can be used as a natural food preservative. Its use partially avoids sterilization which is beneficial to retain the nutrition and flavor of the food. Xu (2007) found that the optimal parameter when extracting the natural preservative from *H. cordata* using alcohol was a 1:15 solid/liquid ratio at 80°C for 10 h. The main strains which were inhibited by the volatile oils extracted from *H. cordata* in the food industry are shown in Table 4 (Xiong et al., 2002; Tang et al., 2005). To determine the best preparation conditions for essential oil-β-cyclodextrin inclusion complex from *H. cordata*, an L^9 (3^4) matrix was used to examine the effects of four factors, and the inclusion rate of each test was determined orthogonally. The best condition was oil-β-cyclodextrin-water = 1:8:80 (mL:g:mL), stirring for 1 h at 40°C. The resultant complex was stable and showed a high inclusion rate (He et al., 2005).

Medicinal utilization of H. cordata

H. cordata has been used as TMC for thousands of years. In Chinese ancient medicine, infusion and decoction products of the *H. cordata* root and herb were used to prevent and cure diseases. In modern times the plant is gaining increasing popularity in the medical field for

Table 4. Antimicrobial effect of the *H. cordata* extract.

Strain	Bacteriostatic diameter/mm	Antimicrobial minimum consistence/mic
Staphylococcus aureus	9.0~19.8	0.25~0.8
Escherichia coli	8.7~11.4	0.6~1
Bacillus subtilis	5.8~10.3	0.6~2
Penicillium	5.4~6.3	8
Aspergillus niger	3.4~5.5	8
Budding fungus	6~7.2	8

health promotion and adjuvant therapy. At present, the extracts and some products of *H. cordata* are used to treat respiratory problems, surgical diseases, gynecological diseases, infectious diseases, refractory hemoptysis, malignant pleural effusion and nephrotic syndrome, and so on (Zhou et al., 1999; Xu, 2002; Wu et al., 2006).

Future trends

H. cordata has been a time-honored TCM. Recently, clinical applications of *H. cordata* have increased. Although a number of studies have reported that *H. cordata* is effective in antiviral, antibacterial and anti-inflammatory functions, few studies have been conducted to examine the concentrations of pharmacological mechanisms for different diseases. Further attention has been paid to the side effects of the *H. cordata*. The results of some studies show *H. cordata* is available for several diseases afflicting mankind. Therefore, future studies will focus on the pharmacological components and functional mechanism of *H. cordata*.

H. cordata contains abundant nutritional and active ingredients, including volatile oils, flavonoids and water soluble polysaccharides. However, the products of *H. cordata* have not been widely accepted by consumers, and the application and development of potential products are lagging behind. In view of this, further research related to *H. cordata* utilization would not only be a scientific challenge but also an interesting economic pursuit.

With the increasing demand for the products of *H. cordata*, cultivated plants are gradually appearing. It is time for a series of good manufacturing practices to be mapped out to utilize the high-yield, environmentally friendly, high-quality resource of *H. cordata*.

Acknowledgements

This project was supported by National Key Technology R&D Program 2006BAD27B04.

***Declaration of interest*:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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