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Review

A review of medicinal plant species with elemene in China

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Some researchers suggest that many plant species or extracts have medicinal value; in particular, some have great antitumor potential. *Rhizoma curcuma* is the dried roots of *Curcuma phaeocaulis*, *C. kwangsinensis* and *C. wenyujing* in Chinese herbal medicine and the essential oil from it has been shown to inhibit tumor cell growth mainly due to its elemene component. Elemene has marked the characteristic of wide spectrum of antineoplastic activity and low adverse toxicity, especially *β*-elemene. Commercialized elemene injection is produced by *R. curcuma*, and applied as a national second-class new drug of antitumor in China. Literature reveals that many other plant species contain *β*-elemene or isomers in their essential oils from plant or parts of plant, and may represent a potential alternative to *R. curcuma* in the elemene processing industry and for use in antineoplastic medicine. This review summarizes the list of plants studied for their constituents of essential oils, and forty-four plant species are given much attention.

Key words: Elemene, plant species, medicine, *Rhizoma curcuma*.

INTRODUCTION

Cancer has taken the leading cause of mortality all over the world and many drugs have been developed and are developing to treat it (Jemal et al., 2009). In China, various Chinese herbal medicines have also been developed and employed in cancer treatment. Many studies have demonstrated beneficial effects of Chinese herbal medicine or its extracts on the survival rates/time, quality of life and immune function of cancer patients when used alone or in conjunction with conventional therapies like chemotherapy (Zhou et al., 2005). Some Chinese herbal medicines have also been shown to increase the responsiveness of cancer to conventional therapies and to alleviate radiation-induced xerostomia, chemotherapy-induced leucopoenia, nausea and vomiting. Other studies have proved that some Chinese herbal medicines or extracts are beneficial for relieving symptoms related to cancer such as pain, and may offer an alternative approach to standard care for advanced cancer (Zhang, 2000; Wang et al., 2007), such as camptothecin, paclitaxel, and ginsenoside (Shen et al., 2010). Elemene is also one of the essential components extracted from *Rhizorra Curmuma* used in Chinese herbal medicine.

Since the groundbreaking works on elemene were conducted by Shi (1981) and Guo et al. (1983), interest in elemene has increased dramatically. Fu et al. (1994) isolated *β*-elemene, γ-elemene and δ-elemene from *R. curcuma* which in Chinese herbal medicine is the dried roots of *Curcuma phaeocaulis*, *C. kwangsinensis* and *C. wenyujing*. Since then, many studies have been conducted and *β*-elemene has marked the characteristics of wide spectrum of antineoplastic activity, alleviating the aches cancer-caused, and increasing leukocyte improving

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immune function, synergetic effect with chemotherapy or radiotherapy, etc. Most importantly, it has been shown to have low adverse toxicity by contrast with most anti-cancer drugs used clinically (Tang et al., 2010; Rui et al., 2007). Elemene injection commercialized with the main ingredient *β*-elemene and a small amount of γ-elemene and δ-elemene and other terpenoids, is produced by *R. curcuma* and has already been an application as a national second-class new drug of anti-tumor in China (Li et al., 2005). For the purpose of hunting for better water solubility and anti-tumor activity derivatives, structural modifications of *β*-elemene have been designed, such as glycoside derivatives containing heteroatom S or Se (Yang et al., 2008), *β*-elemene mono-substituted amino acid (Cheng et al., 2008), radioactive derivative of $Re(CO)_3$ (Cheng et al., 2007), *β*-elemene-13-yl alkyl selenides (Hong-Xing et al., 2008) etc. But none of these derivatives' anti-tumor activity has been examined. Another isomer, γ-elemene has also been determined from many plants and its anti-tumor activity has not been examined too (Figure 1).

Herbs have been the basis of traditional Chinese medicines and continue to provide new remedies to human kind; therefore, a great deal of effort has been devoted to identifying useful chemicals from plants. Actually, recent reports indicate that there are many plant species with elemene in their essential oils. In some of them, the relative contents of elemene are very high. However, only *R. curcuma* is used in the elemene processing industry up till now. This review covers medicinal species with high content of elemene, mostly native to China, and the purpose is to survey the total elemene content of medicinal plants and to evaluate potential sources for elemene injection for medicinal purposes. Of all the reviewed species, forty-four species listed subsequently were given much attention

AN OVERVIEW OF THE METHODS USED TO ASSAY ELEMENE CONTENT

Elemene is one of the volatile natural compounds. Volatile compounds are usually referred to essential oils, which are liquid, volatile, limpid, insoluble in water and soluble in organic solvents with a generally lower density than that of water (Bakkali et al., 2008). Essential oil can be isolated from the plant's tissue by using distillation, solvent extraction, solid phase micro-extraction and supercritical fluid extraction. It has been found that gas chromatography-mass spectrometry (GC-MS) is the most common and reliable method to identify the component of essential oils.

Distillation accounts for the major share of essential oils being produced today. Hydrodistillation is one of the oldest and easiest methods being used for the extraction of essential oils. In this method, the raw plant material is fully dipped in water. When heated, volatile compounds along with steam are condensed and separated in another vessel connected to the heater by a pipe. The only difference for steam distillation from hydrodistillation is that the raw plant material should be separated from boiling water. The distillate generated by distillation will be purified by solvent extraction (Eiri Board, 2011). Organic solvents are preferred, such as methanol, ethanol, ether, petroleum ether and acetic ether. Distillation requires a relatively large amount of sample and some volatile components will be lost at the high extraction temperature. Compared to distillation, solvent extraction works at lower temperatures, which reduces the energy consumption and some heat-sensitive compounds can be conserved and extracted. It also extracts non-volatile resinous components with the volatile compounds (Huang et al., 2009). Only solvent extraction is not good when estimating elemene content. Solid phase micro-extraction is a relative new sampling and concentration method. Originally developed for the analysis of pollutants, this method is suitable for detecting volatile compounds emitted by plants (Tholl et al., 2006; Mayre et al., 2008). It is a simple, sensitive and solvent-free technique for analysis of volatile compounds from an herb sample (Belliardo et al., 2006).

Headspace solid phase micro-extraction in combination with gas chromatography-mass spectrometry (GS-MS) has been used for analysis of volatile compounds (Zhang et al., 2007), and it is pretty good to determine elemene content in herbs. Supercritical fluid extraction is environmentally benign, avoiding the use of organic solvents. Supercritical fluid extraction has shown some advantages as compared to the former traditional extraction methods using organic solvents or distillation. For example, the potential to process stuffs at mild temperatures under chemically inert conditions and using CO_2 as an extraction fluid also results in a low environmental impact. Using CO_2, that is supercritical CO_2 extraction, supercritical fluid extraction meets most of the requirements of the Montreal Protocol for solvents that do not contribute to ozone depletion. In addition, when using CO_2 as an extracting solvent, the extraction selectivity can be varied through adjustment of the pressure and/or temperature (Javier et al., 2003; Abbas et al., 2008). However, supercritical fluid extraction has its limitations. The required consumes energy, and large investment is needed for the equipment.

GS-MS is a widely used assay like identifying and quantifying volatile and semi-volatile organic compounds in mixtures, determining molecular weights and elemental compositions of unknown organics in mixtures, structurally determining unknown organics in complex mixtures both by matching their spectra with reference spectra and by a priori spectral interpretation (Settle, 1997), and for these functions it is employed to estimate the elemene content in many studies.

Although, many methods are available to extract essential oils, it is important to employ a consistent and

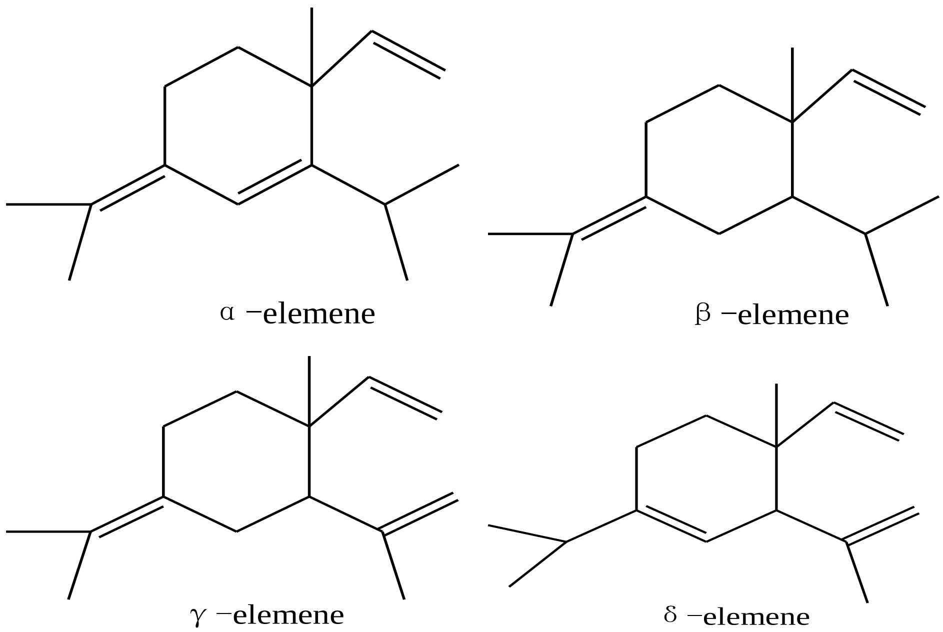

Figure 1. Four isomeric compounds of elemene.

rapid method. While each method has its own merits and drawbacks, the field distillation units are extremely popular due to their very simple construction, cost-effective sample preparation and easy operation. All the methods mentioned have been modified and improved in recent years to exhibit higher analyte enrichment, more quantitative recovery, better accuracy, lower detection limits, etc.

PLANT SPECIES WITH HIGH ELEMENE CONTENT

In the past years, many plant species have been identified with elemene in their essential oils, apart from *C. phaeocaulis*, *C. kwangsinensis* and *C. wenyujing*. In this work, available literatures have been reviewed and much attention has been given to these herbs with high content of elemene in their essential oils. Essential oils from forty-four plant species have been found to contain considerable elemene. They can probably be plant sources in the elemene processing industry as shown in Table 1.

CONCLUSION

This study focused on plants to understand their potential uses in the elemene processing industry belonging to several different families. Unfortunately, none of these plants' antineoplastic activity has been studied *in vitro* or *in vivo* other than *R. curcuma*.

The essential oil from *R. curcuma* contains 27.83% elemene in the industrial processing by supercritical CO_2 extraction. Among the plant species with *β*-elemene or its isomers in their essential oils, four species contain elemene more than 27.83% that is, *Nigella damascena*, *Michelia figo*, *Alisma orientalis,* and *Solidago decurens*. That means they have a brilliant future to be used for raw material in the elemene processing industry.

Essential oil contains many constituents and these constituents have different biological activities, such as *Artemisia annua*, *Sarcandra glabra, Cymbopogon winterianus*, etc. Artemisinin (QingHaoSu, QHS) extracted from *A. annua*, has shown the effect to treat severe malaria, efficiently, quickly and with low toxicity (Qian, 2007). Elemene has also been identified in the essential oil from *A. annua*, but neglected. Phenylpropanoid-substituted catechin glycoside isolated from *S. glabra* was shown to have remarkable potent hepatoprotective activity (Zhu, 2008). Meanwhile, the essential oil contains 15.92% elemene from *S. glabra* analyzed by GC-MS method (Huang et al., 1998). *C. winterianus* is an important natural flavorant, and the essential oil from its leaves is wildly used. The relative content of elemene is 5.12% in the remains of leaves of *C. winterianus* after flavor oil has been extracted (Zhou et al., 2005). Dou et al. (2005) successfully got non-dominant components of citronella oil by vacuum distillation which yielded terpenoid compounds in which the content of elemene is 70%. The mixture has been showed to have antineoplastic activity. Today, we care more about resource conservation. These valuable plant resources should be made full use of, which make much sense.

β-elemene is as the main ingredient in elemene injection that also contains a small amount of *γ*-Elemene, *δ*-elemene and other terpenoids. A large number of

Table 1. Forty-four plant species.

S/N	Species	Methods to prepare essential oils	Assay methods	Isomers and their contents (%)	References
1	*Nigella damascene* (seed)	Hydrodistillation combined with ether extraction and the extract dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (73.24)	Filippo et al. (2002)
2	*Michelia figo* (flower, leaf, rootstock)	Hydrodistillation	GC-MS	*β*-Elemene (33.43, 32.71, 33.58), γ-elemene (11.24, 11.60, 10.23), δ-elemene (3.09, 4.88, 3.12) , respectively	Dian et al. (2006)
3	*Michelia macclurei* (leaves)	Hydrodistillation and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (14.56), γ-elemene (9.18), δ-elemene (1.3)	Huang et al. (2009)
4	*Alisma orientalis* (rootstock)	Headspace solid-phase micro-extraction	GC-MS	*β*-Elemene (3.31), δ-elemene (30.41)	Li et al. (2009)
5	*Solidago decurens* (leaves)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (6.92), δ-elemene (21.73)	Zhu et al. (2009)
6	*Inula racemosa* (a cultivated variety, roots)	Steam distillation combined with ether extraction	GC-MS	Elemene (26.77)	Yang et al. (2008)
7	*Magnolia grandiflora* (leaves)	Supercritical CO_2 extraction	GC-MS	*β*-Elemene (18.81), γ-elemene (0.91), δ-elemene (1.02)	Liu et al. (2008)
8	*Atractylodes carlinoides* (roots)	Hydrodistillation	GC-MS	γ-Elemene (18.932)	Zuo et al. (2009)
9	*Chrysanthemum morifolium* var. *jinjuhua*(flowers), *C. morifolium* var. *hangbaiju* (flowers), *C. morifolium* (flowers), *C. morifolium* var. *dayangju* (flowers), *C. morifolium* var. *gongju* (flowers)	Steam distillation combined with ether extraction	GC-MS	*β*-Elemene (17.6, 14.7, 11.6, 5.84, 5.73, respectively)	Jiang et al. (2005)
10	*Kalimeris indiica* (plant)	Steam distillation	GC-MS	γ-Elemene (17.452)	Ma et al. (2002)
11	*Podocarpus nagi* (leaves)	Steam distillation	GC-MS	α-Elemene (7.102), *β*-elemene (9.577)	Yang et al. (2008)
12	*Sarcandra glabra* (plant)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	Elemene (15.92)	Huang et al. (1998)

Table 1. *Contd*

13	*Cinnamomum glanduliferum* (leaves)	Purchased in Yibin area, Sichuan province	GC-MS	β-Elemene (0.15), δ-elemene (13.69)	Lin et al. (1987)
14	*Evodia ruatecarpa* var. *bodinieri* (green fruit)	Headspace solid-phase micro-extraction, steam distillation extraction and the distillate dried over anhydrous sodium sulfate and petrol ether extraction , respectively	GC-MS	α-Elemene (0.66), β-elemene (11.79), γ-elemene (1.0)	Yang et al. (2009)
15	*Fortunella crassifolia* (peel)	Steam distillation	GC-MS	α-Elemene (1.33), β-elemene (1.86), γ-elemene (3.77), δ-elemene (4.52)	Huang et al. (2007)
16	*Mangifera indica* (fragrances from commercial ripe fruit and full ripe fruit)	Thermal-desorption cold trap	GC-MS	β-Elemene (9.21), γ-elemene (2.61)	Zheng et al. (2008)
17	*Gynura divaricata* (roots, stem, leaves)	Steam distillation combined with acetic ether extraction	GC-MS	Elemene (4.00, 6.26, 10. 63, respectively)	Xian et al. (2008)
18	*Dipterocarpus tubinatus* (stem)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	β-Elemene(0.9), α-elemene(9.50)	Ren et al. (2007)
19	*Ainsliaea pertyoides* var. *albotomentosa* (plant)	Steam distillation	GC-MS	β-Elemene(6.38), γ-elemene(3.23)	Li Xiang et al. (2006)
20	*Aglaia odorata* (flowers)	Purchased in Fuzhou, Zhangzhou and Chongqing	GC	β-Elemene(9.30)	Lin et al. (1981)
21	*Zingiber mioga* (flowers)	Steam distillation combined with ether extraction and the extract dried over anhydrous sodium sulfate	GC-MS	β-Elemene (7.31), γ-elemene (0.86)	Lv et al. (2004)
22	*Polygonatum cyrtonema* (roots)	Steam distillation combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	β-Elemene (8.611)	Yu et al. (2008)
23	*Hyssopus cuspidatus* (plant)	Steam distillation combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	γ-Elemene (8.35)	Fu et al. (2008)
24	*Alpinia oxyphylla* (fruit)	Soxhlet extraction by petroleum ether	GC-MS	β-Elemene (4.50), γ-elemene (3.38)	Chen et al. (2010)

Table 1. *Contd*

25	*Kadsura coccinea* (roots)	Steam distillation	GC-MS	*β*-Elemene (7.03). γ-elemene (0.80)	Peng et al. (2006)
26	*Lantana camara* (leaves, flowers)	Steam distillation combined with ether extraction and the distillate dried over anhydrous magnesium sulfate	GC-MS	*β*-Elemene (5.735, 3.149), γ-elemene (0.946, 1.059), γ-elemene (1.148, 0.952), respectively	Zhou (2009)
27	*Angelica keiskei* (plant)	Steam distillation combined with normal hexane extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	γ-Elemene (7.42)	Zhang et al. (2010)
28	*Notopterygium incisum* (roots)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (6.78), γ-elemene (0.15), δ-elemene (0.54)	Yang et al. (2006)
29	*Leonurus sibirieus* (plant)	Steam distillation	GC-MS	*β*-Elemene (trace), γ-elemene (6.50)	Wang et al. (1991)
30	*Scutellaria baicalensis* (plant)	Steam distillation combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	γ-Elemene (6.23)	Gong et al. (2009)
31	*Dictamnus dasyarpus* (root bark)	Steam distillation	GC-MS	*β*-Elemene (4.41), δ-elemene (1.61)	Li et al. (2006b)
32	*Angelica sinensis* (roots)	Solid phase micro-extraction	GC-MS	γ-Elemene (5.92)	Liu et al. (2007)
33	*Aristolochia debilis* (roots)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	α-Elemene (5.60)	Qiu et al. (2005)
34	*Schefflera kwangsiensis* (stem)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (5.146)	Xu et al. (2005)
35	*Elsholtzia rugulosa* (plant)	Supercritical CO_2 extraction combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	δ-Elemene (4.98)	Hu et al. (2006)
36	*Clausena excavate* (leaves)	Steam distillation combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (4.09), δ-elemene (0.71)	Na (2006)

Table 1. *Contd*

37	*Hydrocotyle sibthorpoioides* (plant)	Steam distillation	GC-MS	*β*-Elemene (5.80), γ-elemene (0.41)	Mu et al. (2004)
38	*Nardostachys chinensis* (roots)	Steam distillation	GC-MS	Elemene (5.93)	Li (2009)
39	*Parakmeria nitida* (leaves)	Steam distillation combined with ether extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (3.23), γ-elemene (2.383)	Yang et al. (2009)
40	*Piper puberulum* (plant)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	*β*-Elemene (5.22), δ-elemene (0.22)	Teng et al. (2009)
41	*Daucus carota* (fruit)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	γ-Elemene (5.27)	Wang et al. (2003)
42	*Hypericum patulum* (plant)	Steam distillation and the distillate dried over anhydrous sodium sulfate	GC-MS	Elemene (4.98)	Zhang et al. (2009)
43	*Myoporum bontiodes* (plant)	Steam distillation combined with ether extraction and the distillate dried over anhydrous magnesium sulfate	GC-MS	γ-Elemene (4.93)	Xu et al. (2006)
44	*Ligustrum robustum* (leaves)	Steam distillation combined with dichloromethane extraction and the distillate dried over anhydrous sodium sulfate	GC-MS	γ-Elemene (5.80)	Tong et al. (2004)

experiments proved elemene injection were applications as a national second-class new drug of anti-tumor in China in 1994. Over the years, further basic researches were related to elemene injection, which had a significant inhibitory effect on a variety of tumor cells, as well as tumor cell apoptosis and differentiation, reversal of multidrug resistance of tumor cells and anti-metastases. Combined with radiotherapy and immunity, and mild toxicities.

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REFERENCES

Abbas KA, Mohamed A, Abdulamir AS, Abas HA (2008). A Review on Supercritical Fluid Extraction as New Analytical Method. Am. J. Biochem. Biotechnol. 4(4):345-353.

Bakkali F, Averbeck S, Averbeck D, Idaomar M (2008).

Biological effects of essential oils: A review. Food Chem. Toxicol. 46:446-475.

Chen S, Chen F, Liu H (2010). Analysis of the Volatile Oil from the seed of *Alpinia oxyphylla* by Soxhlet extraction. Cereals Oils Process. 9:25-27.

Cheng KM, Shen YM, Wang MH (2008). Synthesis of *β*-Elemene amino acid derivatives. Chin. J. Appl. Chem. 25(5):560-563.

Cheng KM, Sheng YM (2007). Radioactive synthesis of *β*-Elemene Re $(CO)_3$ derivative. NI. J. Clear Tech. 30(1):53-56.

Dian L, Gong X, Cai C (2006). Analysis on chemical constituents of *Michelia figo* Spreng. Chin. Hosp. Pharm. J. 26(10):1250-1252.

Dou Y, Li D, Liu S (2005). Non-dominant components of citronella oil and their tumorostatic activity. Shanxi Med. J. 34(5):375-376.

Eiri Board (2011). Hand Book of Medicinal and Aromatic Plants. Accessed on 9 January. http://assamagribusiness.nic.in/NEDFi/map23.pdf.

Filippo L, Antuono D, Alessandro M, Antonio FS, Lovato (2002). Seed yield, yield components, oil content and essential oil content and composition of *Nigella sativa* L. and *Nigella damascena* L. Ind. Crops Prod. 15:59-69.

Fu J, Zhang L (2008). GC-MS Analysis of the Volatile Oil from *Hyssopus cuspidatus* in Xinjiang. Chin. Tradit. Patent Med. 30(3):413-414.

Fu NW, Jin LP, Huo YT (1994). Antitumor and pharmacological studies of *β*-elemene. Bull. Chin. Med. 9:35.

Gong J, Ni S, Liu Y (2009). Study on the volatile oil from aerial part of *Scutellaria baicalensis* Georgi by GC-MS. J. Anhui Agric. Sci. 37(32):15844-15845.

Guo YT, Wu XY, Chen YR (1983). Determination of elemene from the volatile oil of *Curcuma wenyujing.* Chin. J. Chin. Mat. Med. 3:31.

Hu H, Zhang X (2006). Study on extraction, separation and antimicrobial activity of volatile oil from *Elsholtzia rugulosa*. Chin. Hosp. Pharm. J. 26(1):14-17.

Huang B, Qin L, Chu Q, Zhang Q, Gao L, Zheng H (2009). Comparison of Headspace SPME with hydrodistillation and SFE for analysis of the volatile components of the roots of *Valeriana officinalis* var. *latifolia*. Chromatographia 69(5-6):489-496

Huang L, Huang R, Zhang H (2007). Gas Chromatography-mass Spectrometry analysis on the chemical constituents of *Fortunella crassifolia* Peel volatile oil. J. Fujian Normal Univ. 23(4):92-95.

Huang R, Tan D, Zheng Y (2009). Chemical constituents of the volatile oils from leaves of *Michelia macclurei* Dandy. J.Trop. Subtrop. Bot. 17(4):406-408.

Huang R, Xie P, Jian-dong (1998). GS-MS analysis of essential oil from *Sareandra glabra* (Thunb.) Nakai. Chin. Tradit. Patent Med. 20(1):37-38.

Javier SF, Elena I, Alejandro C (2003). New trends in food processing. Critical Rev. Food Sci. Nutr. 43(5):507-526.

Jemal A, Siegel R, Ward E, Hao Y, Xu J, Thun MJ (2009). Cancer statistics, 2009. CA Cancer J. Clin. 59:225–49.

Jiang H, Li F, Zeng S (2005). Capillary GC determination of *β*-Elemene, camphor and borneol in *Chrysanthemum morifolium* Ramat. Chin. J. Pharm. Anal. 25(5):508-511.

Li L, Wu Q (2009).GS-MS analysis on the volatile oil from *Alisma orientalis* extracted by headspace extraction. Northwest Pharm. J. 24(2):111-113.

Li X, Deng Y, Zhang X (2006b). Study on the chemical constituents of the essential oil in *Ainsliaea pertyoides*. Chem. Res. Appl. 18(9):1132-1136.

Li X, Wang G, Zhao J (2005). Antiproliferative effect of beta-elemene in chemoresistant ovarian careinoma cells is mediated through arrest of the cell cycle at the G2-M phase. Cell Mol. Life Sci. 62(7-8):894-904.

Li Y (2009). Study on the active composition of *Radixet rhizoma nardostachyos.* MSc. Thesis, Chengdu University of Traditional Chinese Medicine.

Li ZG, Lee MR, Shen DL (2006). Analysis of volatile compounds emitted from fresh *Syringa oblata* flowers in different florescence by headspace solid-phase microextraction-gas chromatography-mass spectrometry. Anal. Chim. Acta 576(1):43-49.

Lin Z, Hua Y, Gu Y (1981). A Study on the chemical constituents of the essential oils of the flowers of *Aglaia odorata* Lour. Acta. Bot. Sin. 23(3):298-302.

Lin Z, Hua Y (1987). Chemical Constituents of 14 essential oils from Lauraceae growing in Yibin area, Sichuan Province. Chem. Ind. For. Prod. 7(1):46-64.

Liu Q, Zhang F, Wang Q (2007). Analysis of volatile organic compounds of *Angelica sinensis* (Oliv.) Diels by Solid Phase Microextraction (SPME) and GC-MS. J. Instrumental Anal. 26(6):898-900.

Liu Y, Wang H (2008). Extraction of the Volatile Oil from the Leaves of *Magnolia grandiflora* L. with Supercritical Fluid Extraction and Its component analysis. Fine Chem. 25(6):573-576.

Lv Q, Qin J, Chen T (2004). GC-MS Analysis of chemical constituents in volatile oil from the flowers of *Zingiber mioga* Rosc. Phy. Testing Chem. Anal. Part B Chemical Analysis. 40(7):405-408.

Ma Y, Jiang D (2002). Composition of Essential Oils in Indian Kalimeris. Econ. For. Res. 20(2):69-71.

Mayre V, Schaber D, Hadacek F (2008). Volatiles of myrmecophytic *Piper* plants signal stem tissue damage to inhabiting Pheidole ant-partners. J. Ecol. 96:962-970.

Mu S, Wang Y, Hao X (2004). Study on Chemical Constituents of Volatile Oils from *Hydrocotyle sibthorpoioides* LAMS Nat. Prod. Res. Dev. 16(3):215-218.

Na Z (2006). Chemical components of essential oil in *Clausena excavate* leaves. Acta Bot. Boreal-Occidentalia Sin. 26(1):0193-0196.

Peng F, Deng H (2006). Analysis on the compounds of the volatile oil from *Radix Kadsurae* Coccineae by GC-MS. J. Modern Food Pharm. 16(4):6-8.

Qian G (2007). Extraction and Purification of Artemisinin from *Artemisia annua* L. Ph.D. Dissertation, Zhejiang University.

Qiu Q, Zhao-jie Z,Guo-ying (2005). A study on chemical constituents for the essential oil of *Aristolochia debilis Sieb.* & Zucc. by supercritical fluid extraction and steam distillation. J. Shandong Univ. 40(1):103-108.

Ren H, Zhou B (2007). Study on the Essential Oil of *Dipterocarpus tubinatus* Wood. Flavour Frag. Cosmet. 5:5-7.

Rui D, Xiaoyan C, Taixiang W (2007). Elemene for the treatment of lung cancer. Cochrane Database Syst. Rev. 17(4):CD006054.

Settle FA (1997). Handbook of Instrumental Techniques for Analytical Chemistry. Prentice Hall PTR, Upper Saddle River, New Jersey. 993 pp.

Shen LH, Wang SL, Zhu TC (2010). Research and Application of Anti-Tumor Activity Components of Plants. Chin. Agric. Sci. Bull. 26(8):74-78.

Shi JH (1981). Pharmacological studies on antitumor activities of *β*-elemene. Bull. Chin. Med. 2:32.

Tang Xh, Qin SK, Xie T (2010). Status and progress of basic researches of elemene injection for anti-tumor. Chin. Clin. Oncol. 15(3):266-272.

Teng J, Zhu Y, Cai Y (2009). Chemical analysis on volatile oil of *Piper puberulum* by GC-MS. Li Shi Zhen Med. Material Med. Res. 20(12):3027-3028.

Tholl D, Boland W, Hansel A, Loreto F, Rose, Schnitzlre (2006). Practical approaches to plant volatile analysis. Plant J. 45:540-560.

Tong H, Gao A, Yuan H (2004). Volatile oils of kudingcha from *Ligustrum henryi* and *Ligustrum robustrum*. J. Plant Resour. Environ. 13(1):53-55.

Wang JP, Ge XG, Wang Y (2007). High intensity focused ultrasound combined with Chinese herbal medicine for controlling pain in pancreas cancer. Liaoning J. Tradit. Chin. Med. 34:1607-1608.

Wang X, Sun Y (2003). Analysis of chemical constituents in volatile oil from *Daucus carota* L. Chin. J. Spectrosc. Lab. 20(4):530-532.

Wang X, Zhu Z (1991). Study on the essential oil from 3 *Leonurus* species. J. Chin. Med. Mater. 14(11):35-36.

Xian H, Zhou R, Liu W (2008). Determination of the essential oil from different parts of *Gynura divaricata* (L.) DC. by GC-MS. LiShiZhen Med. Mater. Med. Res. 19(4):858-859.

Xu N, Bai H, Yan X (2006). Analysis of Volatile Components in Essential Oil of *Chimonanthus nitens* by Capillary Gas Chromatography-Mass Spectrometry. J. Instrumental Anal. 25(1):90-93.

Xu W, Li K, Yuan X (2005). GC-MS Analysis of essential oil from *Schefflera kwangsiensis*. J. Chin. Med. Mater. 28(6):471-471.

Yang LY, Zhang SJ, Zheng XF (2008). Design and Synthesis of *β*-Elemene glycoside derivatives containing Heteratom S or Se. Chem. J. Chin. Univ. 29:2187-2190.

Yang R, Yuan X, Du H (2008). GS-MS analysis on the volatile oil from *Podocarpus nagi.* Asia-Pacific Tradit. Med. 4(5):51-52.

Yang S, Cao Q, Zhang Y (2009). Chemical composition and biological activity of volatile oil from *Parakmeria Nitida*. J. Fujian Forestry Sci. Tech. 36(1):38-42.

Yang W, Yang Z, Qian-song HE (2009). Analysis of volatile components in *Evodia ruatecarpa* (Juss.) Bneht. var. bodinieri (Dode) Huang with different extraction methods by GC-MS. Fine Chem. 26(5):458-461.

Yang X, Zhang P, Tao H (2006). GC-MS analysis of essential oil constituents from rhizome and root of *Notopterygium incisum*. J. Chin. Pharm. Sci. 15(3):172-177.

Yang Y, Hu F, Ma S (2008). Determination of chemical compositions of the essential oil from cultivated variety *Inula racemosa* Hook. f. Based on GC-MS Method. J. Anhui Agric. 36(25):10950-10951.

Yu H, Zhang X, Deng M (2008). Study on constituents and biological activity of volatile oil from tubers of *Polygonatum cyrtonema* Hua. Chin. J. Exp. Tradit. Med. Formulae 14(5):4-7.

Zhang C, Qi M, Shao Q, Zhou S, Fu R (2007). Analysis of the volatile compounds in *Ligusticum chuanxiong* Hort. using HS-SPME-GC-MS. J. Pharm. Biomed. Anal. 44(2):464-470.

Zhang J (2000). Effect of Chinese herbal medicine on cancer-associated cachexia. Chin. J. Integr. Tradit. West. Med. 20:871.

Zhang L, Dong G, Liu G (2009). Study on chemical constituents from essential oil of *Hypericum patulum*. J. Chin. Med. Mater. 32(2):224-226.

Zhang X, Tian H, Su X (2010).Chemical constituents analysis of the essential oil from *Angelica keiskei* Koidzumi by GC-MS. J. Anhui Agric. Sci. 38(22):11783-11784.

Zheng H, Zhang H, Zhang R (2008). Ariances of aromatic constituents among "Xiaosannian" Mango fruits from Yunnan Province at different ripe stages on fragrances. Food Sci. 29(10):487-490.

Zhou DH, Lin LZ, Zhou YQ (2005). Analysis of short-term therapeutic efficacy of integrated traditional and Western medicine in treating non-small cell lung cancer. Chin. J. Integr. Tradit. West. Med. 25:1061-5.

Zhou, Xue-song (2005).Study on Separation of Elemene from the Essential Oil of Plants. Master's Thesis, Tianjing University.

Zhou Y (2009).Studies on the chemical constituents in the essential oil from *Lantana Camara* L. Asia-Pacific Tradit. Med. 5(7):25-27.

Zhu L (2008). Study on the hepatoprotective activity of *Sarcandra glabra*. Master's Thesis, Peking Union Medical College, Chinese Academy of Medical Sciences.

Zhu X, Xu P, Chao Y (2009). Comparison of chemical constituents and antimicrobial activities of volatile oil from *Solidago decurrens* and *S. canadensis*. Scientia Silvae Sinicae 45(4):167-170.

Zuo X, Huang L, Guo L (2009). GS-MS analysis on the volatile oil from *Atractylodes carlinoides*. Chinese Tradit. Herbal Drugs 32(9):1404-1406.