Antioxidant and Antimicrobial Activities of Essential Oil and Extracts of *Saurauia lantsangensis* Hu Root

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Z. Naturforsch. **67 c**, 282–290 (2012); received March 2/October 19, 2011

Antioxidant and antimicrobial activities of the essential oil and *n*-hexane (HEE), chloroform (CHE), ethyl acetate (EAE), and methanol (MEE) extracts, respectively, from the root of *Saurauia lantsangensis* Hu were investigated. The GC-MS analysis revealed 39 compounds representing 96.41% of the oil containing T-muurolol (13.85%), acetophenone (7.46%), α-cadinol (6.26%), methyl palmitate (5.36%), *n*-hexadecanoic acid (4.31%), torreyol (3.69%), and isospathulenol (3.48%) as major components. Antioxidant activities determined by three various testing systems, *i. e.* DPPH radical scavenging, superoxide anion radical scavenging, and reducing power assay, increased in the order: HEE < CHE < oil < MEE < EAE. CHE, EAE, MEE and oil exhibited a promising antimicrobial effect determined as the diameter of zones of inhibition (13.3–16.2, 16.5–20.4, 13.5–16.6, and 16.5–22.7 mm), respectively, along with their respective MIC values (500–1000, 125–500, 250–500, and 250–500 μg/ml) against Gram-negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*), Gram-positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*), and a yeast (*Hansenula anomala*).

Key words: Antioxidant, Antimicrobial, *Saurauia lantsangensis* Hu

Introduction

The inhibition of oxidative reactions in food, pharmaceutical and cosmetic products and the prevention of oxidative stress-related diseases in the human body are the potential functions of antioxidants (Moure *et al*., 2001). The use of synthetic antioxidants, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), *t*-butyl hydroquinone (TBHQ), propyl gallate, and citric acid in foods has led to the appearance of remarkable side effects. For example, these substances can exhibit carcinogenic effects in living organisms (Grice, 1988), enlarge the liver size, and increase the microsomal enzyme activity (Ames, 1983; Ito *et al*., 1983). The existence of microorganisms causes spoilage and results in reduction of the quality and quantity of processed foods. It has been estimated that as many as 30% of people in industrialized countries suffer from a food-borne disease each year, and at least two million people died from diarrhoea-related diseases worldwide in 2000 (WHO, 2002). Some natural compounds, such as essential oils, phenolics, flavonoids, anthocyanins, and carotenoids, isolated from herbs or spices, have been of great interest as naturally and biologically produced antioxidants or antimicrobials (Schuenzel and Harrison, 2002; Bozin *et al*., 2006; Vagionas *et al*., 2007; Wei and Shibamoto, 2007).

The genus *Saurauia* comprises about 300 species in the world. Thirteen of them are found in China (Wang *et al*., 2008). Most plants of the genus *Saurauia* are used as folk medicines in China. *S. lantsangensis* is mainly distributed in tropical and subtropical areas in Asia. The bark and root have been used in folk medicine for treatment of ulcer, carbuncle, wounds and other symptoms. So far, a few studies on *Saurauia* species (*S. napaulensis, S. excelsa*) have been carried out. Previous phytochemical studies showed that the major chemical components of these species are terpenoids (Wang *et al*., 2008; Teixeira and Garbarino, 1984).

The purpose of the present study was to evaluate the antioxidant and antimicrobial efficacy of the essential oil and solvent extracts from underground parts of *S. lantsangensis* grown in the Gaoligong Mountains, Yunnan Province, China.

Material and Methods

Chemicals and reagents

1,1-Diphenyl-2-picrylhydrazyl (DPPH), nitro blue tetrazolium (NBT), methionine, and riboflavin were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Butylated hydroxytoluene (BHT) was purchased from Sinopharm Chemical Reagent Co. (Shanghai, China). Streptomycin and tetracycline were purchased from CBIO Bioscience & Technologies Co. (Beijing, China). All other chemicals and solvents used in this study were of analytical grade and obtained from Jinhuada Chemical Reagent Co. (Guangzhou, China).

Plant material

Fresh roots of *S. lantsangensis* were collected in Gaoligong Mountains, Yunnan Province, China, in June 2007 and identified by Dr. Xun Gong (Sun Yat-Sen University, Guangzhou, China). The samples were air-dried in the shade (at room temperature). A voucher specimen (No. 474249) was deposited in the South China Botanical Garden (Guangzhou), Chinese Academy of Sciences.

Isolation of the root essential oil

The dried root (200 g) of *S. lantsangensis* was chopped and subjected to hydrodistillation for 3 h using a Clevenger-type apparatus. The oil was dried over anhydrous Na_2SO_4 and preserved in a sealed vial at 4 °C until further analysis.

Gas chromatography-mass spectroscopy (GC-MS) analysis

Quantitative and qualitative analysis of the essential oil was performed using a GC-MS instrument (Model 6890-5975 GC-MS; Agilent Technologies, Ltd., Palo Alto, CA, USA) equipped with an HP-5 MS fused silica capillary column (30 m × 0.25 mm i.d., film thickness 0.25 μm). For GC-MS detection, an electron ionization system with an ionization energy of 70 eV was used. Helium gas was used as a carrier gas at a constant flow rate of 1 ml/min. Injector and mass transfer line temperature were set at 250 and 280 °C, respectively. The essential oil solution (1 μl) in *n*-hexane was injected and analysed with the column held initially at 40 °C for 1 min which was then increased to 250 °C with a 3-°C/min heating ramp, and subsequently kept at 250 °C for 20 min. The relative percentage of the oil constituents was expressed as percentage by peak area normalization. The identity of the components of the oil was assigned by comparison of their retention indices relative to a series of *n*-alkane indices on the HP-5 MS capillary column and GC-mass spectra from the Nist05 and Rtlpest3.

Extraction

The dried powder (250 g) of *S. lantsangensis* root was respectively extracted for 72 h in a rotary shaker with 2000 ml each of *n*-hexane, chloroform, ethyl acetate, and methanol in a conical flask at 30 °C. The extracts were filtered and concentrated using a rotary evaporator (RE-52A; Shanghai Woshi Co., Shanghai, China).

Determination of total polyphenols content

The total phenolics content of each extract was determined by the method of Singleton and Rossi (1965). Two ml of extract solution containing 1.0 g extract in a volumetric flask were diluted with 45 ml of distilled water. One ml of Folin-Ciocalteau reagent was added and mixed thoroughly. Three min later 3.0 ml of 2% sodium carbonate were added, and the mixture was allowed to stand for 3 h with intermittent shaking. The absorbance of the blue colour that developed was read at 760 nm. The total phenolics content of organs was expressed as mg gallic acid equivalents per gram of dry weight (mg GAE/g DW) using a calibration curve with gallic acid, ranging from 0 to 500 μg/ml. All samples were analysed in triplicate.

Estimation of total flavonoids content

The total flavonoids content was measured by a colorimetric assay according to Dewanto *et al.* (2002). An aliquot of diluted sample or standard solution of rutin was added to 75 μl of $NaNO_2$ solution (5%) and mixed for 6 min before adding 0.15 ml $AlCl_3$ (10%). After 5 min, 0.5 ml of NaOH was added. The final volume was adjusted to 2.5 ml with distilled water and the mixture thoroughly mixed. Absorbance of the mixture was determined at 510 nm against a blank in which the sample was omitted. The total flavonoids content was expressed as mg rutin equivalents per gram of DW (mg RE/g DW) using a calibration curve with rutin, ranging from 0 to 500 μg/ml. All samples were analysed in triplicate.

Total condensed tannins assay

The analysis of condensed tannins (proanthocyanidins) was carried out according to the method of Sun *et al.* (1998). To 50 μl of properly diluted sample, 3 ml of 4% vanillin solution in methanol and 1.5 ml of concentrated HCl were added. The mixture was allowed to stand for 15 min, and the absorption was measured at 500 nm against methanol as a blank. The amount of total condensed tannins was expressed as mg (+)-catechin equivalents per gram of DW (mg CE/g DW). The calibration curve of catechin was established between 0 and 500 μg/ml. All samples were analysed in triplicate.

DPPH radical scavenging activity

The DPPH radical scavenging activities of the test samples were evaluated by the method of Blois (1958) with minor modifications. Initially, various concentrations (25, 50, 75, and 100 μg/ml) of sample extracts (0.1 ml) were mixed with 1 ml of 0.2 mM DPPH (dissolved in methanol). The reaction mixture was incubated for 20 min at 28 °C in the dark. The control used as blank contained all reagents without the sample. The DPPH radical scavenging activity was determined by measuring the absorbance at 517 nm using a spectrophotometer. The DPPH radical scavenging activity (%) of the test sample was calculated as: DPPH scavenging effect (%) = $(A_{control} - A_{sample}/A_{control}) \cdot 100$, where $A_{control}$ is the absorbance of the control reaction, and A_{sample} is the absorbance of the test compound. The DPPH radical scavenging activity of BHT was assayed for comparison.

Superoxide anion radical scavenging activity

The superoxide anion radical scavenging activity was determined as described by Beauchamp and Fridovich (1971) with some modifications. All solutions were prepared in 0.2 M phosphate buffer (pH 7.4). Various concentrations (25, 50, 75, and 100 μg/ml) of sample extracts (0.1 ml) mixed with 3 ml of reaction buffer solution (pH 7.4) containing 1.3 μM riboflavin, 0.02 M methionine, and 5.1 μM NBT. The reaction solution was illuminated by exposing it to two 30-W fluorescent lamps for 20 min, and the absorbance was measured at 560 nm. The reaction mixture without sample was used as control. The superoxide anion radical scavenging activity (%) was calculated as: superoxide anion radical scavenging activity (%) = $(A_{control} - A_{sample}/A_{control}) \cdot 100$, where $A_{control}$ is the absorbance of the control reaction, and A_{sample} is the absorbance of the test compound. The superoxide anion radical scavenging activity of BHT was also assayed for comparison.

Determination of reducing power

The reducing power assay was done according to the method of Oyaizu (1986) with little modification. Various concentrations (25, 50, 75, and 100 μg/ml) of sample extracts (0.1 ml) were mixed with phosphate buffer (2.5 ml, 0.2 M, pH 6.6) and potassium ferricyanide (2.5 ml, 1%). After the mixture had been incubated for 20 min at 50 °C, trichloroacetic acid (2.5 ml, 10% w/v) was added to each sample and the mixture centrifuged at 1510 x *g* for 10 min. A 5-ml aliquot of the upper layer was mixed with distilled water (5 ml), and ferric chloride (1 ml, 0.1%) was added; then the absorbance was measured at 700 nm against a control which contained all reagents without the test sample. The higher absorbance indicated higher reducing power. The reducing power of BHT was also determined for comparison.

Test microbial strains

The *in vitro* antimicrobial activity of the essential oil and various solvent extracts of *S. lantsangensis* root was evaluated against five pathogenic microorganisms, *viz*. *Pseudomonas aeruginosa* CCTCC AB93066, *Escherichia coli* CCTCC AB91112, *Bacillus subtilis* CCTCC AB92068, *Staphylococcus aureus* CCTCC AB91053, and *Hansenula anomala* CCTCC AY92046 procured from China Center for Type Culture Collection (CCTCC), Wuhan, China. All strains were stored in the appropriate medium before use.

Inhibitory effect by the disc diffusion method

A standard agar diffusion method was used for the antimicrobial assay (Murray *et al.*, 1995). LB medium (20 ml) was poured into a Petri dish and allowed to solidify. Plates were dried, and 0.1 ml of standardized inoculum containing 10^7 to 10^6 CFU/ml of bacterial suspension was poured and uniformly spread; then the inoculum was allowed to dry for 5 min. A Whatman No. 1 sterile filter paper disc (6 mm in diameter) was impregnated with 1000 μg/disc of essential oil and extracts of

n-hexane, chloroform, ethyl acetate, and methanol, respectively. Negative controls were prepared using the same solvent employed to dissolve the samples. Standard reference antibiotics, streptomycin and tetracycline (10 μg/disc), were used as positive controls for the tested bacteria. The plates were incubated at 37 °C for 24 h. Antimicrobial activity was evaluated by measuring the diameter of the zones of inhibition against the tested organisms. The experiments were done in triplicate, and the results were expressed as average values.

Determination of minimum inhibitory concentration (MIC)

The MIC of the essential oils was determined by the two-fold serial dilution technique (Baker *et al.*, 1980). Dilutions of the essential oils and various solvent extracts were prepared in Mueller-Hinton broth (Hi Media, Mumbai, India) ranging from 0.06 to 125 μl/ml. To each tube 0.5 ml of the inoculum containing approximately 10^8 CFU/ml microorganisms was added. A control test was also performed containing inoculated broth supplemented with only dimethyl sulfoxide under identical conditions with gentamicin as reference. All tubes were then incubated at 37 °C for 24 h and examined for evidence of the growth.

Statistical analysis

Tests were carried out in triplicate and the results were calculated as means ± SD.

Results

Chemical composition of the essential oil

The hydrodistillation of the air-dried roots of *Saurauia lantsangensis* Hu root gave a dark yellowish oil with a yield of 0.27% (w/w). The GC-MS analysis of the essential oil resulted in the detection of 39 components representing 96.41% of the oil (Table I). The essential oil was found to be rich in oxygenated sesquiterpenes (36.24%), esters (17.50%), sesquiterpenes (12.57%), and oxygenated monoterpenes (3.64%). Major components of the oil were T-muurolol (13.85%), acetophenone (7.46%), α-cadinol (6.26%), methyl palmitate (5.36%), *n*-hexadecanoic acid (4.31%), torreyol (3.69%), and isospathulenol (3.48%).

Table I. Chemical composition of the essential oil of *S. lantsangensis* root.

RI[a]	Component	RA (%)[b]	Identification methods[c]
1034	Phenyl methanol	2.02	MS, RI
1098	α-Linalool	0.57	MS, RI
1100	*n*-Undecane	1.45	MS, RI
1122	Phenylethyl alcohol	2.49	MS, RI
1168	Borneol	1.32	MS, RI
1200	Dodecane	0.70	MS, RI, Co
1286	Bornyl acetate	1.77	MS, RI
1358	Eugenol	1.75	MS, RI
1386	β-Cubebene	0.87	MS, RI
1421	β-Caryophyllene	1.59	MS, RI
1432	Octyl-2-methylbutanoate	1.36	MS, RI
1438	γ-Elemene	1.72	MS, RI
1458	Acetophenone	7.46	MS, RI
1470	Isohomogenol	1.63	MS, RI
1486	Germacrene D	2.87	MS, RI
1500	*n*-Pentadecane	0.61	MS, RI
1505	β-Bisabolene	0.97	MS, RI
1527	Dodecanoic acid methyl ester	1.35	MS, RI, Co
1530	Cadina-1,4-diene	1.69	MS, RI
1534	α-Cadinene	2.86	MS, RI
1577	Caryophyllene oxide	1.55	MS, RI
1589	Globulol	1.35	MS, RI
1600	*n*-Hexadecane	0.63	MS, RI, Co
1626	Isospathulenol	3.48	MS, RI
1642	T-Muurolol	13.85	MS, RI
1649	Torreyol	3.69	MS, RI
1652	β-Eudesmol	2.78	MS, RI
1653	Pogostol	3.28	MS, RI
1655	α-Cadinol	6.26	MS, RI, Co
1700	*n*-Heptadecane	0.79	MS, RI
1706	Norphytan	1.04	MS, RI
1810	Phytan	1.48	MS, RI
1850	Hexahydrofarnesyl acetone	0.49	MS, RI
1905	(*Z*)-7-Hexadecenoic acid methyl ester	1.6	MS, RI
1928	Methyl palmitate	5.36	MS, RI
1931	14-Methyl-pentadecanoic acid methyl ester	2.52	MS, RI
1971	*n*-Hexadecanoic acid	4.31	MS, RI
1996	Hexadecanoic acid ethyl ester	2.87	MS, RI, Co
2095	9,12-Octadecadienoic acid methyl ester	2.03	MS, RI
	Total	96.41	

[a] Retention index relative to *n*-alkanes on an HP-5 MS capillary column.
[b] Relative area (peak area relative to the total peak area).
[c] RI, retention index; MS, mass spectroscopy; Co, co-injection with authentic compound.

Total polyphenols, flavonoids, and condensed tannins contents of extracts

The extraction process yielded 7.6 g of material in the *n*-hexane extract, 11.5 g of material in the chloroform extract, 13.4 g of material in the ethyl acetate extract, and 12.6 g of material in the methanol extract from 250 g dried powder of *S. lantsangensis* root.

The amounts of total polyphenols, flavonoids, and condensed tannins material, respectively, of the extracts are given in Table II. The ethyl acetate extract had the highest contents of polyphenols and flavonoids followed by the methanol, chloroform, and *n*-hexane extracts. On the other hand, the contents of total condensed tannins was highest in the methanol extract.

DPPH radical scavenging activity

As shown in Fig. 1, the ethyl acetate extract exhibited an excellent DPPH radical scavenging activity, higher than that of BHT at all concentrations tested. At 50 μg/ml, the highest percentage of DPPH radical scavenging activity of 94.3% was observed in the ethyl acetate extract, significantly higher ($p < 0.05$) than that of BHT (68.3%). From 0 to 100 μg/ml, the DPPH radical scavenging activity of the ethyl acetate extract increased in a dose-dependent manner but less so when the concentration exceeded 50 μg/ml. The methanol extract showed stronger DPPH free radical scavenging activity than BHT at 25 and 50 μg/ml.

Table II. Total polyphenols, flavonoids, and condensed tannins contents, respectively, in various solvent extracts of *S. lantsangensis* root[a].

Extract	Polyphenols (mg GAE/g DW)	Flavonoids (mg RE/g DW)	Tannins (mg CE/g DW)
n-Hexane	11.37 ± 0.21	6.57 ± 0.36	2.33 ± 0.25
Chloroform	31.57 ± 1.13	22.53 ± 1.12	11.72 ± 0.75
Ethyl acetate	73.43 ± 1.31	59.83 ± 0.69	14.32 ± 0.64
Methanol	37.66 ± 0.57	28.36 ± 1.43	15.74 ± 1.12

Values are means ± SD.
[a] GAE, gallic acid equivalents; RE, rutin equivalents; CE, (+)-catechin equivalents; DW, dry weight.

Superoxide anion radical scavenging activity

As shown in Fig. 2, the ethyl acetate exract and methanol extracts exhibited an excellent superoxide anion radical scavenging activity, higher than that of BHT in a dose-dependent manner. At 100 μg/ml, the superoxide anion radical scavenging activity of the ethyl acetate extract, methanol extract, and BHT were (92.4 ± 3.2), (83.6 ± 2.8), and (76.7 ± 3.3)%, respectively.

Reducing power

As shown in Fig. 3, the reducing power of the essential oil and extracts along with BHT increased with their concentration. However, the reducing powers of the samples was found in descending order: ethyl acetate extract > essential oil > methanol extract > BHT > chloroform extract > *n*-hexane extract. The reducing power of the ethyl acetate extract and essential oil, respectively, was found to be excellent, and the methanol extract showed lower reducing power.

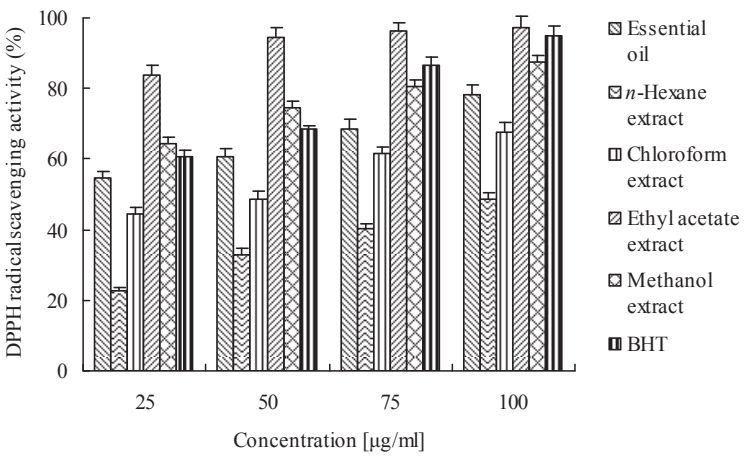

Fig. 1. DPPH radical scavenging activity of the essential oil and various solvent extracts of *S. lantsangensis* root.

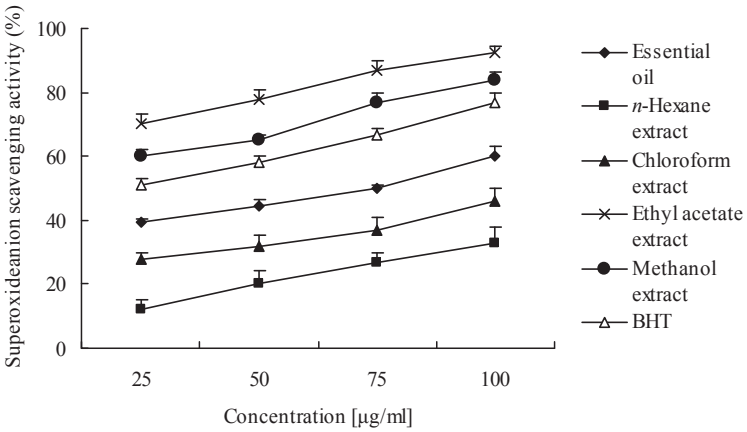

Fig. 2. Superoxide anion radical scavenging activity of the essential oil and various solvent extracts of *S. lantsangensis* root.

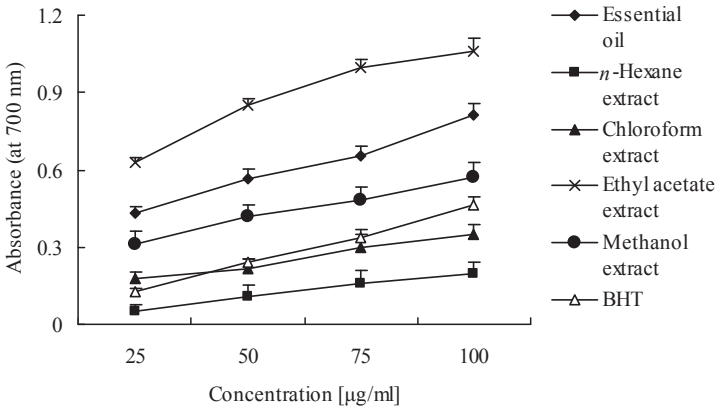

Fig. 3. Reducing power of the essential oil and various solvent extracts of *S. lantsangensis* root.

Antimicrobial activity

As shown in Table III, the essential oil exhibited a potent inhibitory effect against the tested microbial pathogens. *E. coli*, *B. subtilis*, and *S. aureus* were most sensitive to inhibition by the oil. Rest of the microbial strains, *P. aeruginosa* and *H. anomala*, were inhibited moderately. The ethyl acetate extract exhibited potent antimicrobial activity against the tested bacteria as compared to the chloroform extract and the methanol extract. The methanol extract and the chloroform extract exhibited moderate antimicrobial activity against some of the bacterial pathogens. The *n*-hexane extract did not exhibit significant antimicrobial activity against the tested bacteria except *B. subtilis* and *H. anomala*.

Minimum inhibitory concentrations

As shown in Table IV, the ethyl acetate extract exhibited a remarkable antimicrobial effect at low concentration against all test microorganism. The essential oil and the methanol extract exhibited a moderate antimicrobial effect with MIC values ranging from 250 to 500 μg/ml. The chloroform extract exhibited a moderate antimicrobial effect against *B. subtilis* and *S. aureus* and a weak antimicrobial effect against *P. aeruginosa*, *E. coli*, and *H. anomala*. No antimicrobial effect of the *n*-hexane extract was observed (MIC <2000 μg/ml) against any of the microbial strains tested.

Discussion

Plant-based secondary metabolites such as found in essential oil and extracts are widely

Table III. Antimicrobial activity of essential oil and solvent extracts derived from *S. lantsangensis* root.

Microorganism	Diameter of zones of inhibition [mm]						
	Essential oil[a]	Extract[b]				Standard[c]	
		n-Hexane	$CHCl_3$	EtOAc	MeOH	SM	TC
Pseudomonas aeruginosa	16.7 ± 0.9	nd[d]	15.5 ± 1.2	17.4 ± 1.1	15.8 ± 1.3	20.4 ± 0.6	21.3 ± 0.7
Escherichia coli	19.6 ± 1.1	nd	13.3 ± 0.8	16.5 ± 1.6	13.5 ± 0.8	21.2 ± 0.6	22.0 ± 0.6
Bacillus subtilis	22.7 ± 1.4	9.5 ± 0.6	14.5 ± 1.4	17.3 ± 0.7	16.2 ± 1.6	20.3 ± 0.3	23.5 ± 0.7
Staphylococcus aureus	17.9 ± 1.3	nd	16.2 ± 1.2	20.4 ± 0.8	16.6 ± 1.3	20.3 ± 0.8	23.5 ± 0.6
Hansenula anomala	16.5 ± 1.3	9.8 ± 1.1	15.7 ± 0.8	20.2 ± 0.8	16.5 ± 1.3	20.5 ± 0.7	23.2 ± 0.6

Diameter of inhibition zones (mm) including the diameter of disc (6 mm), values are given as means ± SD of triplicate experiments.
[a] 1000 μg/disc were used in each case.
[b] 1000 μg/disc were used in each case.
[c] Standard antibiotics: SM, streptomycin; TC, tetracycline (10 μg/disc).
[d] nd, antimicrobial activity not detected.

Table IV. Minimum inhibitory concentrations (MIC) of essential oil and solvent extracts of *S. lantsangensis* root against the growth of pathogens.

Microorganism	MIC				
	Essential oil	Extract [μg/ml]			
		n-Hexane	$CHCl_3$	EtOAc	MeOH
Pseudomonas aeruginosa	500	<2000	1000	500	500
Escherichia coli	250	<2000	1000	250	500
Bacillus subtilis	250	<2000	500	125	250
Staphylococcus aureus	250	<2000	500	250	500
Hansenula anomala	500	<2000	1000	500	500

used in the food industry and considered GRAS (generally recognized as safe). Various publications have documented the antioxidant and antimicrobial activity of essential oils and plant extracts (Morris *et al*., 1979). Gaoligong Mountains is one of the areas in the world richest in different medicinal plant species grown in various ecological conditions. Investigation of the antioxidant and antimicrobial properties of these plants has brought the opportunity of producing natural and environmentally friendly new sources of antioxidants and antimicrobials that could replace synthetic compounds.

Free radical scavenging is one of the known mechanisms by which antioxidants inhibit lipid oxidation (Hatano *et al*., 1989). The DPPH radical is a free radical, which has been widely used as a tool to assess the free radical scavenging activity of antioxidants. It was found that the DPPH radical scavenging activity is reduced by the hydrogen-donating ability of antioxidants (Prasad *et al*., 2005). The superoxide radical is the most common free radical generated *in vivo*, which can cause damage to the cells and DNA leading to various diseases (Gülcin *et al*., 2007). It was therefore proposed to measure the comparative interceptive ability of antioxidants to scavenge the superoxide radical. Reducing power is widely used to evaluate the antioxidant activity of polyphenols because the reducing power is associated with antioxidant activity and may serve as a significant reflection of the antioxidant activity (Meir *et al*., 1995; Hsu *et al*., 2006). In the present study, in some cases, the ethyl acetate extract, methanol extract, and essential oil showed higher or similar antioxidant activities as compared to the standard BHT. This is due to highly bioactive compounds such as polyphenols, including tannins and flavonoids, in extracts with polar solvents (Karmanoli, 2002) and the synergistic activity of various phenolics. Similar findings were reported by Prasad *et al*. (2005).

It seems reasonable to assume that the antimicrobial action of the essential oil and extracts might be related to the phenolic compounds present (Cakir *et al*., 2004). Most of the studies on the underlying mechanism have focused on their effects on cellular membranes. Phenolic compounds not only attack cell membranes, thereby affecting their permeability and release of intracellular constituents, such as K^+, glutamic acid (Juven *et al*., 1972), and intracellular RNA (Furr and Russell, 1972), but they also interfere with membrane functions (electron transport, nutrient

uptake, and enzyme activity). Thus, active phenolic compounds might have several targets which could lead to the inhibition of microbial pathogens. The antimicrobial activity was screened using two Gram-negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*), two Gram-positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*), and a yeast (*Hansenula anomala*). The essential oil and various extracts derived from root of *S. lantsangensis* have potential activity against all tested pathogens.

The results obtained in this study showed that the essential oil or the extracts of *S. lantsangensis* may be suggested as a new potential source of natural antioxidant and antimicrobial compounds. There was a good correlation between total phenols content and antioxidant capacity of the extracts. The antioxidant capacity, antimicrobial activity, and phenols content of the ethyl acetate extract were the highest. However, the compounds responsible for the antioxidant activities of the extracts are currently unclear, further works should be performed on the isolation and identification of the compounds in the extracts. In addition, the *in vivo* safety needs to be thoroughly investigated in experimental rodent models prior to their possible application.

Acknowledgements

The authors are grateful for financial support by the National Natural Science Foundation of China (20676041) and by the China Postdoctoral Science Foudation (2004036506).

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