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# Chemical Composition and Antioxidant Activity of Essential Oil of Bamboo Leaves from Four Species in China

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The chemical compositions of essential oil from *Pseudosasa amabilis* (McClure)Keng f., *Pleioblastus gramineus* (Bean) Nakai, *Phyllostachys vivax* f. *aureocaulis* N. X. Ma. and *Indocalamus latifolius* (Keng) McClure obtained by steam distillation were analyzed by gas chromatography and gas mass spectrometry. The relative content of the constituents from the essential oil were determined by area normalization method, then compared and analyzed the experimental result. Sixty eight constituents were separated and identified by GC/MS from four species of bamboo leaves. Nineteen kinds of compounds which all contained in the four species of bamboo leaves and 16 kinds of compounds which all contained in the three bamboo leaves were found. Meanwhile, the effect of scavenging free radicals of essential oil was studied by using the DPPH assays with Trolox as control to evaluate their antioxidant capacities. The essential oil of bamboo leaves from four species all possesses certain antioxidant capacity and showed a positive correlation with the essential oil's concentration. The results provide evidence for studying essential compositions from different species of bamboo leaves for further development.

**Key Words: *Pseudosasa amabilis* (McClure) Keng f., *Pleioblastus gramineus* (Bean) Nakai, *Phyllostachys vivax* f. *aureocaulis* N. X. Ma., *Indocalamus latifolius* (Keng) McClure, Essential components, GC/M S, Antioxidant activity.**

## INTRODUCTION

The bamboo is an evergreen plant. The leaves of bamboo have characteristics of slightly astringent, cold property, sweet taste and functions of detoxification, diuresis, improving the eyesight and hemostasis[1]. The main functional ingredient of extract of bamboo leaves is flavonoid glycosides. Some reports[2,3] that the bamboo leaves flavonoid glycosides possess antibacterial and antioxidant activity, which can be used as bioflavonoid health nutrients. In recent years, both the foreign and domestic scholars have preliminarily studied the volatile components of bamboo leaves[4,5] and found that the volatile components contain very good, natural and low toxicity fragrance components, which possess activity of antioxidant, antibacterial and insecticides, *etc*.

The resources of *Pseudosasa amabilis* (McClure) Keng f., *Pleioblastus gramineus* (Bean) Nakai, *Phyllostachys vivax* f. *aureocaulis* N. X. Ma. and *Indocalamus latifolius* (Keng) McClure are very rich in Zhejiang Province of China. Because of their own biological characteristics, such as large-leaves and low-pole, they can be good leaf-using bamboo species. After document retrieval, there were no reports on *Pseudosasa amabilis, Pleioblastus gramineus* and *Phyllostachys vivax* f. *aureocaulis's* leaves in the chemical constituents of volatile oil. This research adopts steam distillation to extract the essential oil from bamboo leaves, GC/MS to analyze the chemical compositions of them, area normalization method to determine the relative content of them and DPPH assays to evaluate their antioxidant capacities.

## EXPERIMENTAL

Agilent 7890A GC and Agilent 5975C MS (U.S. Agilent Inc.), Infinite M 200 enzyme micro-plate reader (Switzerland Tecan), pipette gun (Beijing Keeven Zhuoli Precision Equipment aviation instrument Co., Ltd), *etc*.

The fresh leaves of *Pseudosasa amabilis, Pleioblastus gramineus, Phyllostachys vivax* f. *aureocaulis* and *Indocalamus latifolius* were collected at the beginning of April, 2010 at Jade Garden of Zhejiang Agricultural and Forestry University, China. The species were identified by Xin-Chun Lin Professor from Discipline of Silviculture, Zhejiang Agricultural and Forestry University. The samples were washed and dried at 40 ºC in oven, then was powdered for use.

**Extraction of essential oil:** The volatile oil of bamboo leaves was extracted by steam distillation according to essential oil item of Chinese Pharmacopoeia[6]. 200 g of powdered bamboo leaves were weighted into a 1000 mL distillation flask, 700 mL of distilled water was added. Using volatile oil extractor, the collected distillate was extracted by ether. Ether extract was dehydrated by anhydrous sodium sulfate and the ether was recycled and then obtained the oil of bamboo leaves. The essential oil was pale yellow liquid, which had a strong aroma. The yield of *Pseudosasa amabilis, Pleioblastus gramineus, Phyllostachys vivax* f. *aureocaulis* and *Indocalamus latifolius* were 1.5, 1.3, 1.6 and 1.8 %, respectively.

**Conditions of the GC-MS analysis:** The analysis was carried out on an Agilent GC-MS instrument, fitted with a HP-5MS 30 m × 0.25 mm × 0.25 μm film thickness capillary column and FID detector. The temperature program used for analysis was as follows: initial temperature at 50 °C for 2 min, programmed at 10 °C $min^{-1}$ to 130 °C, then programmed at 5 °C $min^{-1}$ to 180 °C, last programmed at 10 °C $min^{-1}$ to 250 °C and kept 15 min. The injector temperature was set at 250 °C. Helium (99.999 %) was used as the carrier gas at a flow-rate of 1.0 mL $min^{-1}$. No split. The electron impact ionization conditions were as follows ion energy 70 eV and the mass range scanned was 41-450 A.M.U in the full-scan acquisition mode. The compounds were identified using the NIST2008 Mass spectral search program.

### Antioxidation assay

**Preparation of sample:** 21.2 mg synthesized antioxidant Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was weighed and then was fixed volume to 25 mL by alcohol. Mass concentration of the obtained solution of Trolox was 0.848 mg/mL and then was serially diluted from 0.01272, 0.01696, 0.0212, 0.02544, 0.02968 to 0.03392 mg $mL^{-1}$. The extracted essential oil was taken 150 μL by pipette gun to fixed volume 10 mL using alcohol, also serially diluted from 1.5, 3.0, 4.5, 6.0, 7.5 to 9.0 μL $mL^{-1}$.

**Preparation of DPPH• solution:** 0.0285 g DPPH was accurately weighed and was fixed volume to 100 mL. The solution of DPPH was shaken up and placed at refrigerator for use.

**DPPH Assay:** The method was based on the reduction of colour of alcoholic DPPH solution in presence of a hydrogen donating antioxidant. DPPH solutions showed a strong absorption band at 517 nm with a deep violet colour[7]. When the organic scavenger was in presence, the lone-pair electrons were paired, absorption disappeared or weakened, which can evaluate the activity of organic scavenger. 200 μL of each sample (with various concentrations) was added to 100 μL of DPPH ethanol solution. After mixing gently and standing at 24 ºC for 0.5 h, the absorbance was measured at 517 nm using an enzyme micro-plate reader. The percentage of DPPH which was scavenged was calculated using the following formula: Scavenging % = 1-(Ap-Ac)/Amax × 100 %, where, Ap was the stable absorbance of DPPH ethanol solution (100 μL) plus sample solution (200 μL), Ac was the stable absorbance of alcohol (100 μL) plus sample solution (200 μL) and Amax was the stable absorbance of DPPH ethanol solution (100 μL) plus alcohol (200 μL).

## RESULTS AND DISCUSSION

Taken 100 μL prepared essential oil extracted by the referred method to the sample battle and diluted it with 500 μL ether. The injection volume was 0.2 μL. According to the above GC/MS conditions, the essential oil was analyzed and identificated by the GC-MS equipment. Finally, total ion current chromatograph of four species of essential oil was acquired (Fig. 1.). After scanning of each chromatography peaks, the mass spectrum was obtained. By the search of NIST2008 standard

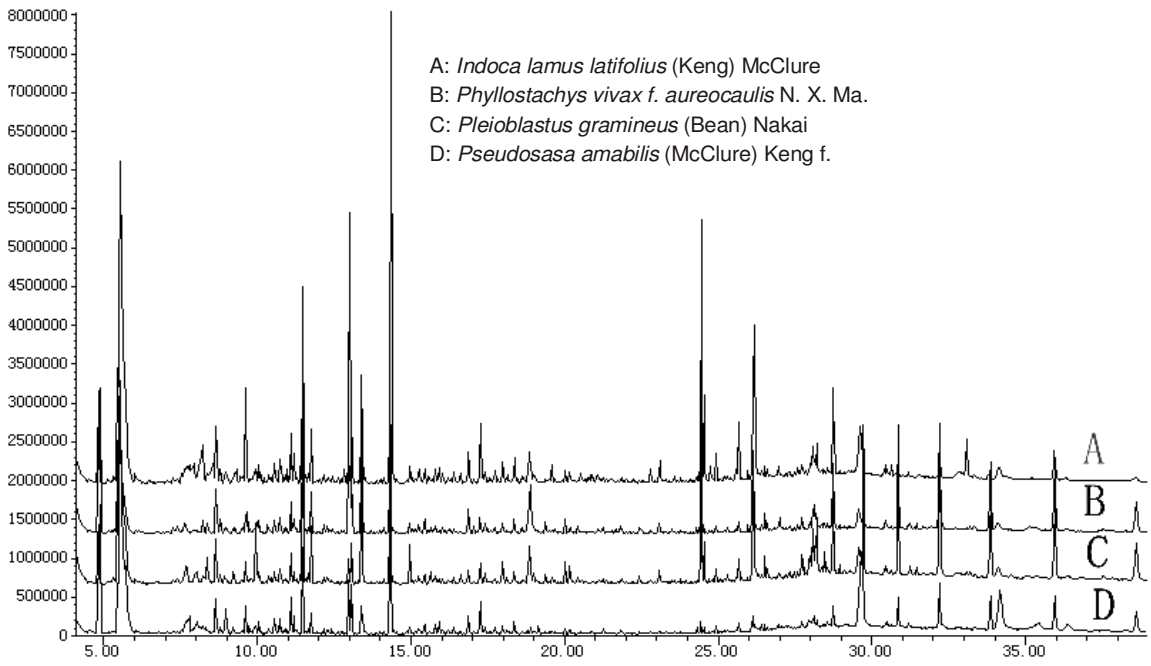


Fig. 1. GC-MS total ion current chromatogram of the essential oil from four different species of Bamboo leaves

MS library and turn to the information about MS, combined with manual analysis, the chemical components of essential oil from the four species of bamboo leaves was identificated. Finally, the relative contents of the constituents from the essential oil were determined using area normalization method (Table-2).

Thirty eight constituents were separated and identified from the essential oil of leaves of *Pseudosasa amabilis*, which accounted for over 94.73 % of total essential oil fraction. The main components of the essential oil from leaves of *Pseudosasa amabilis* were 3-hexen-1-ol (27.423 %), tetratriacontane (9.527 %), eugenol (7.685 %), 1,3,5-trioxepane (7.361 %), 2,3-dihydro-benzofuran (2.474 %), (E)-2-hexenal (2.221 %), benzyl alcohol (2.038 %) and indole (2.025 %), *etc*. Fourty five constituents were separated and identified from the essential oil of leaves of *Pleioblastus gramineus*, which accounted for over 94.31 % of total essential oil fraction. The main components of the essential oil from leaves of *Pleioblastus gramineus* were 3-hexen-1-ol (19.531 %), cedrol (8.82 %), octacosane (4.546 %), 6,10,14-trimethyl-2-pentadecanone (4.136 %), octanoic acid (3.279 %), 2-amino-4-methoxy-phenol (3.228 %) and indole (3.175 %), *etc*. Fourty two constituents were separated and identified from the essential oil of leaves of *Phyllostachys vivax* f. *aureocaulis*, which accounted for over 94.48 % of total essential oil fraction. The main components of the essential oil from leaves of *Phyllostachys vivax* f. *aureocaulis* were indole (14.685 %), 3-hexen-1-ol (11.543 %), 1,3,5-trioxepane (8.289 %), heptacosane (4.187 %), 2-amino-4-methoxy-phenol (3.921 %), hexatriacontane (3.708 %), dodecanoic acid (3.593 %), palmitic anhydride (3.293 %) and (E)-2-hexenal (3.045 %), *etc*. Fourty eight constituents were separated and identified from the essential oil of leaves of *Indocalamus latifolius*, which accounted for over 94.49 % of total essential oil fraction. The main components of the essential oil from leaves of *Indocalamus latifolius* were 3-hexen-1-ol (24.149 %), eugenol (12.975 %), *n*-hexadecanoic acid (5.396 %), 2,3-dihydro-benzofuran (3.396 %), 2-amino-4-methoxy-phenol (3.003 %) and (E)- 2-hexenal (2.704 %), *etc*. Sixty eight constituents were separated and identified by GC/MS from four species of bamboo leaves' essential oil. Nineteen kinds of compounds which all contained in the four species of bamboo leaves and 16 kinds of compounds which all contained in the three bamboo leaves were found, of which, relative content of 3-hexen-1-ol was the highest, which is the second only in *Phyllostachys vivax* f. *aureocaulis*, less than indole. The major common components of the essential oil of the four species are 3-hexen-1-ol, indole, eugenol, (E)-2-hexenal, benzyl alcohol, 2-methoxy-4-vinylphenol, hexahydrofarnesyl acetone and so on. The components above were natural spices or can be used as a potential spice to exploit, so they were the major source of the aroma of bamboo leaves.

All the four species of essential oil of bamboo leaves and the synthetic antioxidants Trolox were set respectively in six different concen-trations to determine the antioxidant activity by DPPH, using regression analysis to analyze the result. The concentration as the abscissa, the scavenging rate of free radical as the ordinate, the $IC_{50}$ can be got with the regression equation. The regression equation and the data of the $IC_{50}$ can be found in Table-1.

Table-1 showed that essential oil of all the four species of bamboo leaves had the ability to scavenge the free radical and the function was more stronger with the higher concentration. There was a well linear relationship between the scavenging rate of free radical and the concentration, which means the ability of scavenging the free radical of essential oil have a good dose-effect relationship with the concentration. $IC_{50}$ was a parameter used often to evaluate the antioxidant capacity. It represented the half inhibition concentration ($IC_{50}$), which

TABLE-1
$IC_{50}$ VALUES OF ANTIOXIDATIVE CAPACITIES OF FOUR SPECIES OF BAMBOO LEAVES

| Samples | Regression equation | $R^2$ | $IC_{50}$ (μL/mL) |
|---|---|---|---|
| *Pseudosasa amabilis* | Y = 0.0498X + 0.2074 | 0.9752 | 5.8755 |
| *Pleioblastus gramineus* | Y = 0.0361X + 0.2391 | 0.9911 | 7.2271 |
| *Phyllostachys vivax* f. *aureocaulis* | Y = 0.0310X + 0.2407 | 0.9875 | 8.3645 |
| *Indocalamus latifolius* | Y = 0.0261X + 0.3553 | 0.9950 | 5.5441 |
| Trolox | Y = 18.582X + 0.1418 | 0.9950 | 0.019277 (mg/mL) |

TABLE-2
ANALYTICAL RESULTS OF CHEMICAL CONSTITUENTS OF ESSENTIAL OIL FROM FOUR DIFFERENT SPECIES OF BAMBOO LEAVES

| No. | Name | m.f. | *Pseudosasa amabilis* | | *Pleioblastus gramineus* | | *Phyllostachys vivax* f. *aureocaulis* | | *Indocalamus latifolius* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RT (min) | Area (%) | RT (min) | Area (%) | RT (min) | Area (%) | RT (min) | Area (%) |
| 1 | 1,3,5-Trioxepane | $C_4H_8O_3$ | 4.875 | 7.361 | 4.817 | 1.307 | 4.881 | 8.289 | 4.881 | 2.414 |
| 2 | (E)-2-Hexenal | $C_6H_{10}O$ | 5.452 | 2.221 | 5.44 | 2.624 | 5.453 | 3.045 | 5.445 | 2.704 |
| 3 | 3-Hexen-1-ol | $C_6H_{12}O$ | 5.532 | 27.42 | 5.517 | 19.531 | 5.516 | 11.543 | 5.547 | 24.149 |
| 4 | (1S,3R)-(+)-*m*-Menthane | $C_{10}H_{20}$ | – | – | – | – | – | – | 7.697 | 1.003 |
| 5 | 1-Methyl-2-propylcyclohexane | $C_{10}H_{20}$ | – | – | – | – | 7.63 | 0.905 | – | – |
| 6 | Phenyl-πD-glucoside | $C_{12}H_{16}O_6$ | 7.703 | 1.226 | 7.694 | 1.395 | – | – | – | – |
| 7 | Hexanoic acid | $C_6H_{12}O_2$ | 7.804 | 1.123 | – | – | – | – | 7.799 | 1.59 |
| 8 | (E)-3-Hexenoic acid | $C_6H_{10}O_2$ | 8.059 | 1.697 | 8.033 | 0.998 | – | – | 8.217 | 2.434 |
| 9 | 3-Methyl-3-vinylcyclopentanone | $C_8H_{12}O$ | – | – | 8.357 | 1.069 | – | – | – | – |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Benzyl alcohol | $C_7H_8O$ | 8.625 | 2.038 | 8.63 | 1.891 | 8.634 | 2.521 | 8.66 | 1.888 |
| 11 | Benzeneacetaldehyde | $C_8H_8O$ | – | – | – | – | 8.797 | 0.567 | 8.8 | 0.311 |
| 12 | 5-Ethyldihydro-2(3*H*)-furanone | $C_6H_{10}O_2$ | 8.966 | 1.346 | – | – | – | – | 8.967 | 0.556 |
| 13 | 3-Heptenoic acid | $C_7H_{12}O_2$ | – | – | – | – | – | – | 9.33 | 0.716 |
| 14 | 1-Hydroxy-πnitro-, (. +-.) cyclohexaneethano | $C_8H_{15}NO_4$ | – | – | – | – | – | – | 9.618 | 2.077 |
| 15 | Phenylethyl Alcohol | $C_8H_{10}O$ | – | – | 9.946 | 0.754 | – | – | – | – |
| 16 | 3,7-dimethyl-6-Nonenal | $C_{11}H_{20}O$ | 9.612 | 1.064 | 9.612 | 0.698 | 9.612 | 0.576 | – | – |
| 17 | 5-Isopropyl-2-methylbicyclo[3.1.0]hex-3-en-2-ol | $C_{10}H_{16}O$ | – | – | – | – | 9.976 | 0.741 | 9.952 | 0.341 |
| 18 | 1,2,4,5-tetramethyl-Benzene | $C_{10}H_{14}$ | 10.053 | 0.402 | 10.56 | 0.271 | 10.051 | 0.492 | 10.054 | 0.221 |
| 19 | Octanoic Acid | $C_8H_{16}O_2$ | – | – | 10.735 | 3.279 | – | – | – | – |
| 20 | *p*-Cymene | $C_{10}H_{14}$ | 10.561 | 0.802 | – | – | 10.56 | 0.72 | 10.562 | 0.593 |
| 21 | d-Arabinose | $C_5H_{10}O_5$ | – | – | – | – | 10.73 | 0.839 | – | – |
| 22 | 3-(1-Cyclopentenyl)furan | $C_9H_{10}O$ | 10.724 | 0.545 | – | – | – | – | 10.732 | 0.873 |
| 23 | Naphthalene | $C_{10}H_8$ | 11.091 | 1.165 | 11.091 | 1.313 | 11.091 | 0.952 | 11.094 | 0.912 |
| 24 | Dodecane | $C_{12}H_{26}$ | 11.187 | 0.515 | 11.187 | 0.746 | 11.187 | 0.834 | 11.189 | 0.475 |
| 25 | 2-Acetyl-cyclohexanone | $C_8H_{12}O_2$ | – | – | – | – | 11.392 | 0.358 | 11.405 | 0.247 |
| 26 | 2,3-Dihydro-benzofuran | $C_8H_8O$ | 11.471 | 2.474 | 11.477 | 1.073 | 11.477 | 3.021 | 11.482 | 3.396 |
| 27 | 2-Amino-4-methoxy-phenol | $C_7H_9NO_2$ | – | – | 11.752 | 3.228 | 11.748 | 1.212 | – | – |
| 28 | Ethylmethylmaleimide | $C_7H_9NO_2$ | 11.743 | 0.691 | – | – | – | – | 11.76 | 0.978 |
| 29 | Indole | $C_8H_7N$ | 12.977 | 2.025 | 12.975 | 3.175 | 13.009 | 14.685 | – | – |
| 30 | 1-Methyl-naphthalene, | $C_{11}H_{10}$ | 13.067 | 1.679 | 13.069 | 1.061 | – | – | 13.073 | 1.332 |
| 31 | 2-Methoxy-4-vinylphenol | $C_9H_{10}O_2$ | 13.383 | 1.004 | 13.388 | 0.346 | 13.39 | 3.921 | 13.394 | 3.003 |
| 32 | 1-Ethylidene-1*H*-indene | $C_{11}H_{10}$ | 13.434 | 0.801 | – | – | – | – | – | – |
| 33 | Eugenol | $C_{10}H_{12}O_2$ | 14.336 | 7.685 | 14.328 | 0.424 | 14.325 | 2.716 | 14.369 | 12.975 |
| 34 | 1-(2,6-Trimethyl-1,3-cyclohexadien-1-yl)-2-buten-1-one | $C_{13}H_{18}O$ | – | – | 14.968 | 0.612 | 14.962 | 0.587 | 14.974 | 0.528 |
| 35 | 1,7-Dimethyl-naphthalene | $C_{12}H_{12}$ | 15.448 | 0.444 | 15.64 | 0.756 | 15.446 | 0.541 | 15.455 | 0.401 |
| 36 | 11-Oxatetracyclo[5.3.2.0(2,7).0(2,8)]dodecan-9-one | $C_{11}H_{14}O_2$ | 16.871 | 0.742 | – | – | 16.874 | 0.904 | 16.879 | 0.77 |
| 37 | *trans*-π-Ionone | $C_{13}H_{20}O$ | 17.257 | 1.304 | 17.255 | 1.788 | 17.252 | 0.592 | 17.263 | 1.521 |
| 38 | 1-Hydroxy-6-(4'-chlorobenzyl)-1,2,3,4,5,6-hexamethylcyclohexa-2,4-diene | $C_{19}H_{25}OCl$ | 17.984 | 0.353 | – | – | – | – | 17.991 | 0.544 |
| 39 | 2(4*H*)-Benzofuranone,5,6,7,7a-tetrahydro-4,4,7a-trimethyl-, (R)- | $C_{11}H_{16}O_2$ | 18.366 | 0.473 | 18.365 | 0.646 | 18.364 | 0.525 | 18.372 | 0.643 |
| 40 | Dodecanoic acid | $C_{12}H_{24}O_2$ | – | – | 18.868 | 0.418 | 18.879 | 3.593 | 18.856 | 0.838 |
| 41 | Cedrol | $C_{15}H_{26}O$ | – | – | 20.021 | 8.82 | 20.019 | 0.513 | 20.022 | 0.287 |
| 42 | 3-Hydroxy-πdamascone | $C_{13}H_{20}O_2$ | – | – | 20.169 | 0.869 | – | – | 20.159 | 0.31 |
| 43 | Tetradecanoic acid | $C_{14}H_{28}O_2$ | – | – | 23.089 | 0.264 | 23.081 | 0.408 | 23.102 | 0.491 |
| 44 | 3,7,11,15-Tetramethyl-2-hexadecen-1-ol | $C_{20}H_{40}O$ | 24.438 | 0.284 | 24.451 | 0.669 | 24.434 | 1.003 | 24.442 | 2.08 |
| 45 | Hexahydrofarnesyl acetone | $C_{18}H_{36}O$ | – | – | 24.539 | 4.136 | 24.532 | 0.257 | 24.541 | 1.517 |
| 46 | Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl | $C_{25}H_{42}O_2$ | – | – | – | – | 25.67 | 0.257 | 25.674 | 0.953 |
| 47 | Palmitic anhydride | $C_{32}H_{62}O_3$ | – | – | – | – | 26.136 | 3.293 | – | – |
| 48 | Diisobutyl phthalate | $C_{26}H_{42}O_4$ | 24.929 | 0.198 | 24.928 | 0.264 | – | – | 24.93 | 0.43 |
| 49 | *n*-Hexadecanoic acid | $C_{16}H_{32}O_2$ | – | – | 26.153 | 0.869 | 26.531 | 0.369 | 26.18 | 5.396 |
| 50 | Linoleic acid ethyl ester | $C_{20}H_{36}O_2$ | – | – | – | – | 28.082 | 0.685 | – | – |
| 51 | Hexadecanoic acid, ethyl ester | $C_{18}H_{36}O_2$ | 26.533 | 0.152 | 26.533 | 0.507 | – | – | 26.535 | 0.175 |
| 52 | 2-Methyl-1-hexadecanol | $C_{17}H_{36}O$ | – | – | 27.72 | 0.589 | – | – | 28.211 | 0.773 |
| 53 | *cis*-13-Eicosenoic acid | $C_{20}H_{38}O_2$ | – | – | 27.972 | 1.132 | – | – | – | – |
| 54 | Behenic alcohol | $C_{22}H_{46}O$ | – | – | 28.087 | 1.391 | – | – | – | – |
| 55 | Oleic acid | $C_{18}H_{34}O_2$ | – | – | 28.165 | 1.168 | 28.14 | 0.815 | – | – |
| 56 | 17-Pentatriacontene | $C_{35}H_{70}$ | 28.74 | 0.535 | 28.74 | 1.67 | 28.737 | 1.673 | 28.078 | 1.037 |
| 57 | 3-Dodecenyl-2,5-furandione | $C_{16}H_{26}O_3$ | – | – | – | – | – | – | 28.741 | 1.859 |
| 58 | Pentatriacontane | $C_{35}H_{72}$ | – | – | 29.59 | 2.157 | – | – | – | – |
| 59 | Tetratriacontane | $C_{34}H_{70}$ | 29.667 | 9.527 | – | – | – | – | – | – |
| 60 | 1-Hexacosene | $C_{26}H_{52}$ | 30.856 | 1.265 | 29.733 | 2.773 | 30.857 | 2.98 | | |
| 61 | Heptacosane | $C_{27}H_{56}$ | 32.206 | 2.29 | 30.861 | 3.075 | 32.207 | 4.187 | 30.855 | 0.221 |
| 62 | Octacosane | $C_{28}H_{58}$ | 33.865 | 1.643 | 32.213 | 4.546 | 33.866 | 2.966 | 32.203 | 0.902 |
| 63 | Nonacosane | $C_{29}H_{60}$ | 34.191 | 5.183 | 33.869 | 3.057 | 29.556 | 1.716 | 29.625 | 3.115 |
| 64 | Heneicosane | $C_{21}H_{44}$ | – | – | – | – | 29.729 | 2.708 | 29.725 | 0.46 |
| 65 | Diisooctyl phthalate | $C_{24}H_{38}O_4$ | – | – | – | – | – | – | 33.088 | 1.158 |
| 66 | 7-Isopropyl-3a,3b,9b-trimethyl-2-phenyl-3a,3b,4,5,5a,7,8,9,9a,9b,10,11-dodecahydro acetic acid | $C_{30}H_{40}O_3$ | 35.425 | 1.447 | 34.119 | 1.027 | – | – | 34.15 | 0.739 |
| 67 | Hexatriacontane | $C_{36}H_{74}$ | 35.957 | 2.046 | 35.964 | 3.505 | 35.958 | 3.708 | 35.953 | 1.152 |
| 68 | Tetratetracontane | $C_{44}H_{90}$ | 38.613 | 1.557 | 613 | 2.422 | 38.611 | 2.267 | – | – |

means a certain concentration of the essential oil when the scavenging rate of free radical reaches 50 % and the concentration was lower, the effect of the scavenging was better, so as the antioxidant activity. According to the Table-2, it showed that the order of $IC_{50}$ was that: *Phyllostachys vivax* f. *aureocaulis* > *Pleioblastus gramineus* > *Pseudosasa amabilis* > *Indocalamus latifolius*, which means that the antioxidant activity of the oil of *Indocalamus latifolius's* leaves was the best, the *Phyllostachys vivax* f. *aureocaulis's* was the worst.

According to the reported literature[10,11], the methods of extracting the essential oil from the plants include the method of cold pressing, steam distillation, reflux extraction, supercritical fluid extraction and solid-phase micro-extraction and so on. Compared with other extraction methods, steam distillation have several advantages, including quicker and more complete extraction, saving time and cost and the content of the active ingredients extracted by steam distillation is higher.

A research[12] about extracting essential oil from the leaves of *Lophatherum gracile* Brongn reported that steam distillation (SD) can extract essential oil more completely than supercritical $CO_2$ extraction (SFE-$CO_2$) and solid-phase micro-extraction (SPME). After serious comparison, Steam distillation (SD) was adopted in this research and GC/MS was used to analyze the result. The result showed that the essential oil of the four species of bamboo leaves had some compositions, which were also contained in the essential oil extracted from *Phyllostachys heterocycla* (Carr.) and *Lophatherum gracile* Brongn's leaves, such as 3-hexen-1-ol, eugenol, E-2-hexenal and 2-methoxy-4-vinylphenol. Sixty eight components of the essential oil from the four species of bamboo leaves were identified, of which, 19 components were common in the four species, accounting for 27.94 %. Sixteen components were common among the three of four, accounting for over 23.53 %.

In addition, the antioxidant activity of essential oil of bamboo leaves was determined with the DPPH assay in this research. The essential oil from the four species of bamboo leaves had a certain antioxidant activity, but the difference among them was not very obvious. The order of $IC_{50}$ of the four different species was that: *Phyllostachys vivax* f. *aureocaulis* > *Pleioblastus gramineus* > *Pseudosasa amabilis* > *Indocalamus latifolius*. That means the antioxidant activity of essential oil of *Indocalamus latifolius* leaves was the best, which of *Phyllostachys vivax* f. *aureocaulis* was the worst.

Natural plant antioxidants replacing synthetic antioxidants are the trend in the development of the food industry. Besides[13,14], looking for the substances which can remove the free radicals in the body is also the trend in the development of the modern medicine and the health care industry. The essential oil of the bamboo leaves have the antioxidant activity; so it provides the reference to further developing and utilizing essential oil of bamboo leaves in the food and medicine industry.

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